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REINFORCED CONCRETE ARCH BRIDGE OVER THE YELLOWSTONE RIVER, YELLOWSTONE NATIONAL PARK.

By H. M. Chittenden.*

During the more than 30 years since the Yellowstone National Park was created, the principal attraction of that region, namely, the Grand Canon of the Yellowstone, has been accessible to sightseers only from the left bank of the river, owing to the absence of any bridge for crossing that stream and the turbulent condition of the river which makes crossing by boat impossible within a reasonable distance. A bridge has been in contemplation for many years, but lack of funds has hitherto prevented its construction. This portion of the river being one of great scenic beauty, it was desired to put in a structure appropriate to the situation, and as such a structure would involve heavy cost, it has never been possible until recently to build one.

The most feasible bridge site is at the brink of the Upper Falls of the Yellowstone, where the river gorge narrows to a width of 50 ft., but it was generally considered undesirable to place any artificial structure in that situation and it was decided to place the bridge farther up near the head of the rapids. While this would increase the distance to be traveled in getting to the other side of the river by about a mile, the entire distance is through interesting scenery and really is not a drawback of serious consequence. The upper site is an excellent one except that the span is much greater than that of the lower site. It is just below the first rapid of the river where the stream narrows in between two jutting points of rock which are admirably fitted for the supports of a bridge. The side next to the main road fortunately comes where there is a sharp bend in the road, which gives a good approach to the bridge in either direction.

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VIEW OF UPPER FALLS OF YELLOWSTONE RIVER, YELLOWSTONE NATIONAL PARK.

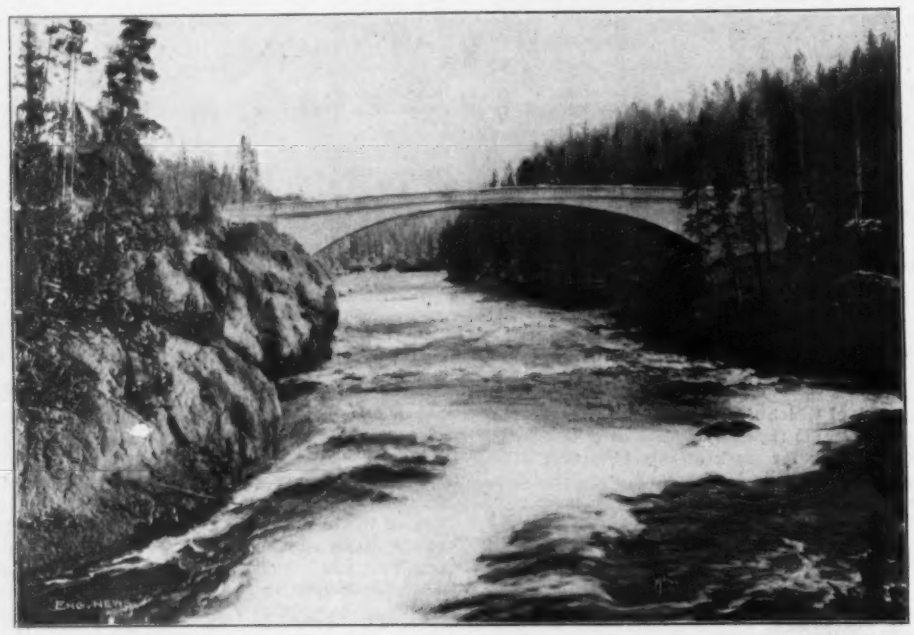
The rock of which the banks of the river is composed is volcanic rhyolite and not of a very satisfactory quality for work of any kind; still from the fact that it has resisted for an idefinite geological period the action of the river, it must have considerable durability. In any case the situation was one that had to be accepted, and as the area over which the pressure from the bridge is distributed is very large, no fear is entertained as to the entire ability of the rock to support the structure.

In deciding upon the style of structure it was thought that some form of arch or suspension bridge would be more suitable than an ordinary steel truss, and as the span was too great for a masonry arch within any practicable limit of expense, it was decided to adopt reinforced concrete construction. The facility with which concrete can be molded to any desired form, and the great strength which can be given to such structures through the use of imbedded steel, and the cheapness of concrete construction, combined in the highest degree the three elements of artistic design, necessary strength, and reasonable cost.

The span of the bridge, is 120 ft. between the ends of the steel arch girders, and 160 ft. between the ends of the bridge. The rise in the steel girders is 15 ft. The surface of the bridge is given an arch form, the center being 2 ft. 6 ins. above the ends. This was done in order to avoid the necessity of going too far down with the spring lines of the arch and at the same time not raise the approaches above the level of the established highway. The effect of this rise in the center of the bridge is pleasing to the eye. The entire width of the structure is 18 ft. 6 ins., and the width of the roadway 14 ft. 6 ins. The concrete railing is 30 ins. high. The height of the bridge floor above low water is 43 ft. The steelwork of the bridge consists of ten arch girders each composed of four angles united by a lattice work. The angles themselves contain the necessary section of steel as computed from the strains to which the bridge will be subjected. It is believed that the lattice girder is better for work of this kind than either a solid beam or two flat bars placed one above the other. In the first place the necessary section of steel can be had as well in one case as the other, while the distance apart of the two sets of angles can be so adjusted as to meet the strains in the best possible way. The lattice union causes both flanges to act together. Finally the open lattice work permits the concrete to be made in a continuous mass through the girder instead of being separated as it would be by a solid web. The dimensions of the angles are ½ x 2½ × 3 ins. The depth of the girder varies from 12 ins. at the center to 22½ ins. at the ends. The concrete arch ring is 24 ins. thick at the crown and 48 ins. at the spring line. The center line of the girders coincide closely with the center line of the arch ring and both with the center line of pressure due to the weight of the structure. The girders are united laterally at intervals of 12 ft. by cross bars of steel bolted to the flanges.

The filling of the spandrels and approaches was made of concrete instead of earth. Both Lehigh and Atlas cements were used, the former in the

1:4:9 mixture for the filling, and the latter in the 1:2:4 mixture for the arch ring, facings and road surface. The 1:2:4 concrete was made of broken rock and washed sand; the 1:4:9 mixture of natural unwashed gravel. A large proportion of boulders (about 200 cu. yds.) was used in the filling. The arch ring and all the filling form one continuous mass. The total volume within the forming was a trifle less than 900 cu. yds.



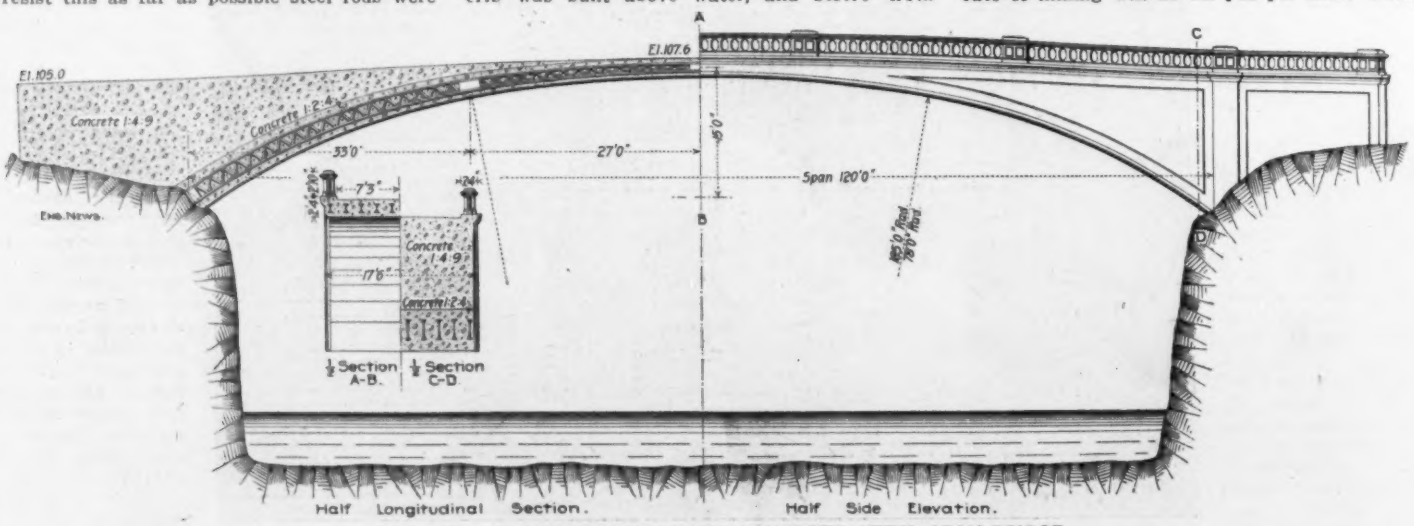
GENERAL VIEW OF CONCRETE-STEEL ARCH OVER THE YELLOWSTONE RIVER, YELLOWSTONE NATIONAL PARK.

A solid concrete construction being decided upon, without earth filling in any part of the bridge or approaches, it was further decided to make the structure act as a solid monolithic mass without any provision for contraction or expansion. It was evident that the greatest strain tending to crack the concrete would come over the spring line where the arch proper joins the approaches. To resist this as far as possible steel rods were imbedded in the concrete 2 ft. below the surface of the bridge parallel to its axis, extending from the ends of the abutments nearly to the center of the bridge. The result of this expedient will be referred to further on.

There is a narrow walk on each side of the bridge, provided with an iron guard rail to prevent injury from the wheels of vehicles. The railing of the bridge is made of concrete cast around a steel channel, which is itself supported by steel bars extending down into the body of the bridge. These bars are enclosed in the concrete of the balustrade.

In the construction of the bridge an important difficulty, and perhaps the greatest of all, was the building of the falsework and the necessary forming. The falsework had to be founded in one of the most violent rapids of the river and was a work of no small risk. The handling of the material was accomplished by means of a steel cable 1¼ ins. in diameter. No especial contrivance was used for transferring the material, reliance being placed upon an ordinary pulley.

The falsework was founded upon two abutments and one pier. The pier consisted of a large crib made of green timber, sunk in as close contact with the bottom of the river as possible, and filled with rock. It rested around a large submerged ledge of rock, which answered the purpose of an excellent anchorage, as it would be impossible for the crib to slip past it. After the crib was built above water, and before much stone was put inside, vertical posts to carry a part of the weight of the structure were placed within the crib in contact with the rock bottom of the river. The weight did not therefore rest entirely upon the crib, but in part upon these posts. After the posts were set up and secured in position the rock filling of the crib was placed. The falsework abutments at the two sides of the river were placed without difficulty as the water at those points was shoal and the current not swift. Upon the pier and abutments above described the falsework was built, each half being sustained by five inverted queen post trusses, as shown in the view on the opposite page.



SECTIONAL ELEVATION OF 120-FT. CONCRETE STEEL ARCH BRIDGE.

All of the material for the upper work was manufactured beforehand and its erection moved off with rapidity after the pier and abutments were once in. A large part of the coarse lumber used in the work was sawed in the vicinity, but all of the finer lumber was brought from the Pacific coast. The work was begun on May 23, and the woodwork was practically finished by Aug. 1.

The lumber and timber of all kinds used in the falsework and forming amounted to over 80,000 ft. B. M. A large part of it was saved and will be available for other uses.

Contrary to the usual practice in putting in structures of this kind, it was decided in the present case not to divide the concrete work into sections, putting in one or more each day, but to carry the work on continuously from start to finish so that the entire mass might set together as a monolith. The only difficulties in executing work in this manner are those of organization and the necessity of assembling a large force and working all night. All details were thought out very carefully and when the concrete was put in the operation passed off without a hitch.

The accompanying sketch plan shows the grounds and the relation of the different piles of material, the mixing boards, bridge, etc., to each other. A careful system of runways was provided to the various gravel and rock piles and to the cement house. Water was brought from the river in road sprinklers and let out into barrels whence it was taken in buckets.

The mixing was done by hand on a single board in a rather unusual way. The board was 25 ft. long, sloping slightly from one end to the other, and 16 mixers were employed, eight on each side. The ingredients were dumped on the upper end and the mixing was begun immediately. The first two mixers turned the material dry. Next to them stood a man with water which he applied after every shovelful. The next mixers kept turning the material along and another water man assisted in wetting the mixture farther down the line. In this way the whole mass was moved along by a sort of continuous motion and when the end of the board was reached it was shoveled directly into the carts below, whence it was wheeled to the bridge. Each batch contained about 18 cu. ft. and made two cartloads. The rate of mixing was 10 cu. yds per hour. Owing to the excessive evaporation the mixture was made as wet as it could be handled.

No mortar facing was used except for the road surface, but great pains was taken to get a close contact with the forms and with the steel arch-beams.

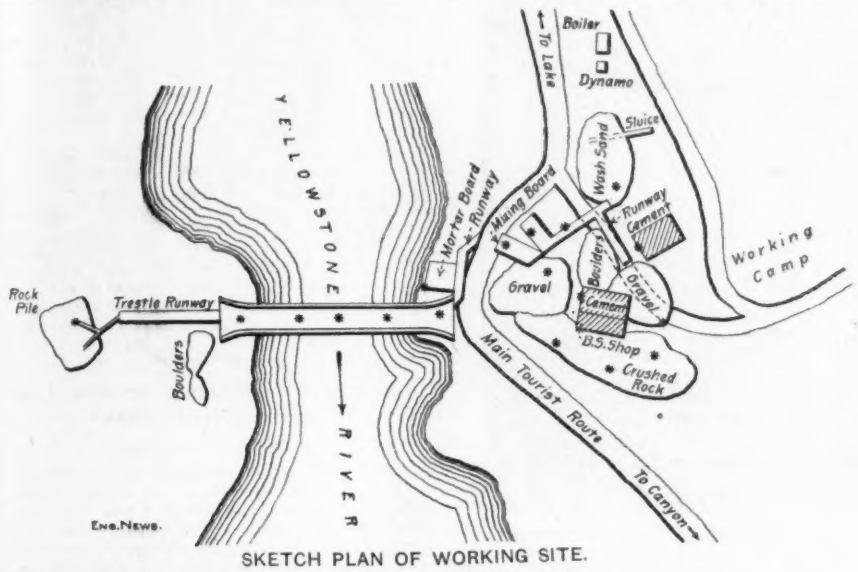
Concreting was begun at the two abutments or approaches and was finished at the center. No appreciable settlement of the falsework was observed.

For carrying out the work, working crews were assembled from different points on the road system to the number of about 150 men. The work was carried on in three shifts of 8 hours each.

The time required with the force available was estimated at 75 hours. Work began at 7 a. m., Aug. 10, and was finished (except the mortar surface of the roadway) at 10 a. m., Aug. 13, a period of 72 hours after deducting three hours for meals.

The time selected for the work was that of the full moon, but artificial light was also necessary. To provide this, a small dynamo was borrowed of the hotel company and was attached to the rock-crusher engine and a temporary plant installed on the grounds. The arrangement was entirely satisfactory.

The work on the railing was commenced immediately after the main body of the concrete was put in. All the forming for the molded portions had been manufactured beforehand and the work of assembling it in place was rapidly done.



SKETCH PLAN OF WORKING SITE.

As is well known, one of the most difficult features of concrete work, when molded in irregular masses, is the construction of the forming. It often happens that the principal difficulty is not in making the forming, but in removing it without injury to the fresh concrete. It is generally of importance to the progress of the work to remove forming at the earliest possible time after the concrete has been put in, and it is therefore very necessary so to construct it that it can be removed without strain upon the concrete.

The arrangement of the forming for the railing of the bridge, particularly for the open spaces under the hand rail, is shown in the accompanying photographs. The center block, after being cut out, was ripped along the axis of the block obliquely with the plane of the face, so that in removing either half the friction on the concrete surface would be relieved the instant motion began. The two parts were held together by two molded pieces which further extended the pattern for that particular part of the railing. These pieces were fastened to the center block with screws so that they could be removed without the shock of nail pulling. With these precautions it was found possible to remove the forming within from two to four days after the mortar was put in.

The centering of the arch was struck Sept. 8, 28 days after the concrete work was completed, A bench mark for level reference had been established and the settlement of the structure on the removal of the supports was carefully measured. It amounted to about one-tenth of an inch.

Very slight cracks have appeared over the spring line on both ends of the bridge, showing that the precautions taken to prevent them were not entirely sufficient. The only possible ill-effect that can come from these cracks will be due to the infiltration of water, and care will be taken to prevent this.

The preparation of the drawings and the supervision of all the work except the putting in of the falsework for the forming was by Mr. Robert Walker, U. S. Overseer. Owing to the temporary absence of Mr. Walker, the falsework was mainly put in by Mr. Frank R. Grunau.

TESTS OF A COMPOUND ENGINE USING SUPERHEATED STEAM.*

By D. S. Jacobus,† M. Am. Soc. M. E.

The engine on which the tests were made was located at the Millbourne Mills in Philadelphia. It is of the Rice & Sargent horizontal cross-compound condensing type, especially designed for using highly superheated steam. A Schmidt superheater is used for superheating the steam.

The tests were made to determine whether certain guarantees were fulfilled which were made by the builders—the Providence Engineering Works. The work was done conjointly by Mr. A. C. Wood and the writer, Mr. Wood representing the purchasers of the engine, and the writer the manufacturers. Mr. A. S. Vogt, Mechanical Engineer of the Pennsylvania R. R. Co., at Altoona, detailed two experienced men from his testing department to assist Mr. Wood, and with other observers and computers, furnished by Mr. Wood, and the staff of the writer, it was possible to check all important data by securing duplicate records.

The high pressure cylinder of the engine was furnished with double-beat poppet valves and the low pressure cylinder with Corliss valves. The inlet and exhaust valves of each cylinder were operated by separate eccentrics. The inlet valves were closed by vacuum dash pots and the exhaust by a positive motion. A portion of the highly superheated steam furnished to the engine passed through a coil in the receiver between the high and the low pressure cylinders. There was a by-pass valve operated by the governor which regulated the amount of steam passing through the coil, a greater amount being made to pass through when the engine was heavily loaded than when it was lightly loaded. There were no steam jackets. The exhaust steam passed from the engine to a Worthington jet condenser connected with a Worthington vacuum pump.

The steam used by the engine was furnished by an Edge Moor water tube boiler. From the boiler it passed to the top of the Schmidt superheater which was set up at the side of the boiler. The saturated steam entering the superheater came in contact with the coldest gases as they left the superheater. From the upper coils the steam passed downward through a pipe outside of the superheater to the bottom of the lowermost set of coils of the superheater, and thus, when only partly heated, was made to pass through the coils which were nearest the fire. This prevented the overheating of the lowermost coils of the superheater, which would have taken place had the steam been made to pass downward all the way through the superheater so as to bring the hottest steam near the fire. From the lowermost set of coils the steam passed upward and back and forth through the coils until it was finally led off from a header directly below the top set of coils and conveyed to the engine. Steam to drive the vacuum pump and for other purposes in the mill was furnished by a separate boiler.

The principal dimensions of the engine, measured when hot, were:

Bore of cylinders.....16.07 and 28.03 ins.
Length of stroke .....42 ins.
Diameter of piston-rods.....3.00 and 3.50 ins.

The average clearance volumes computed from measurements made on the engine and from the working drawings were 4.1% for the high pressure cylinder, and 5.8% for the low pressure cylinder.

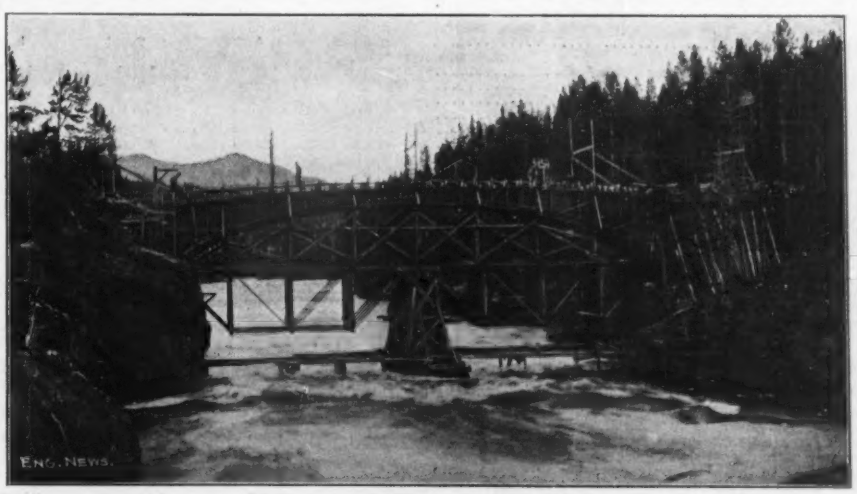
After the tests with superheated steam were completed a test was made with saturated steam. The writer was not present at the test, but was represented by his associate, Prof. F. L. Pryor.

The principal results of the tests are given in detail in Table I. From this it may be seen that the water consumption per hour per indicated horse-power with superheated steam was 9.76 lbs. at 474.5 HP., 9.56 lbs. at 420.4 HP., and 9.70 lbs. at 276.8 HP. The pressure of the steam at the engine throttle was slightly over 140 lbs. per sq. in., and the superheating from about 350° to 400° F. The vacuum measured near the engine ranged from about 25 to 26 ins. of mercury. The heat consumption per minute per indicated horse-power, according to the standard recommended by the Civil Engineers of Great Britain, where the engine is charged with the heat in the steam at the throttle valve and is credited with returning the feed water to the boiler at the maximum possible temperature that could be obtained by a feed water heater in the exhaust pipe, was 205.0 B. T. U. at 474.5 HP., 203.7 B. T. U. at 420.4 HP., and 208.8 B. T. U. at 276.8 HP.

With saturated steam the water consumption was 13.84 lbs. per hour per HP. at 406.7 HP. and the heat consumption 248.2 B. T. U. per minute per indicated horse-power. In this test the vacuum was poorer than in any of the others, being 24.5 ins. It must also be borne in mind that the engine was built for superheated steam, and the cylinder ratio was not what would be used for saturated steam. In computing the heat consumption for this test an allowance is made for the drip from the high pressure steam main at the coil in the receiver. This drip amounted to 280 lbs. per hour over what could be accounted for by the radiation of the steam main from the boiler to the engine. This amount of the high pressure steam was, therefore, condensed in the receiver coil, and imparted heat to the receiver in the same way as an ordinary steam jacket.

Tests were made to determine the economy of the boiler and of the superheater. The coal used was run of mine, Georges Creek, Cumberland. The equivalent evaporation from and at 212° F. per pound of dry coal for the boiler alone was 10.30 lbs., for the superheater it was 8.97 lbs., and for the boiler and superheater combined it was 10.07 lbs. The heat of combustion of the coal determined by means of a Mahler bomb calorimeter was 14,060 B. T. U. per pound. The efficiency of the boiler based on the heat of the coal was 70.7%, of the superheater 61.6%, and of the combined boiler and superheater 69.2%.

The coal consumption may be obtained directly from the heat consumption of the engine already given by mul-

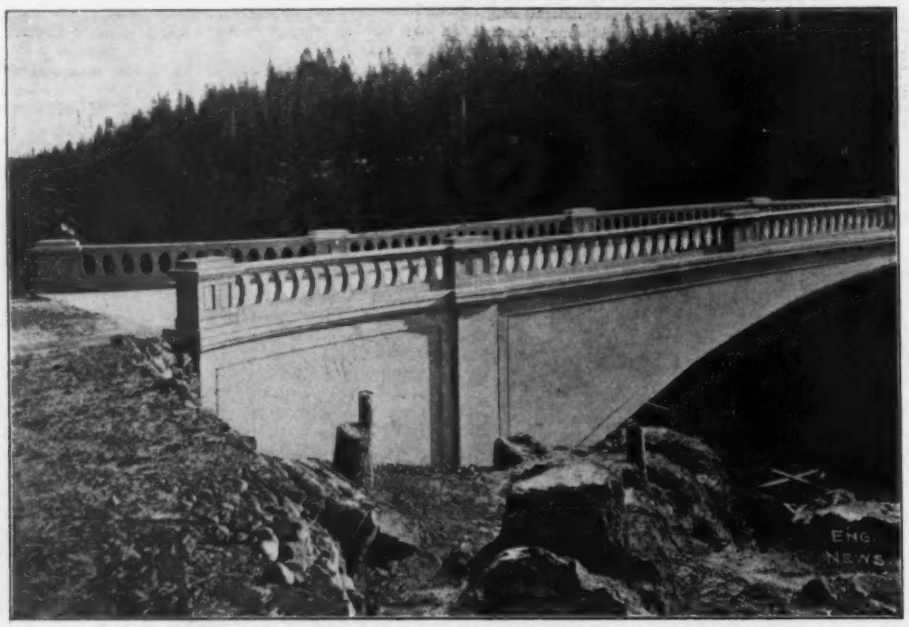


GENERAL VIEW OF CENTERING AND ARCH FORMS.

*A paper presented before the American Society of Mechanical Engineers, at New York, December, 1903.

†Professor of Experimental Mechanics, Stevens Institute of Technology, Hoboken, N. J.

tiplying by 60 and dividing by 9,725 for the superheated steam tests, and by 9,947 for the test with saturated steam, 9,725 being the heat imparted to the boiler and the superheater in British Thermal Units per pound of coal burned in the tests with superheated steam, 9,947 that imparted to the boiler in the test with saturated steam. When computed in this way any loss of heat by radiation in the pipe leading from the boiler to the engine is eliminated, which is a necessary condition in the present case, as the pipe is exceptionally long. On this basis the coal consumption per hour per indicated horse-power for superheated steam was 1.265 lbs. at 475.5 HP., 1.257 lbs. at 420.4 HP., and 1.288 lbs. at 276.8 HP. For the test with saturated steam the coal consumption was 1.497 lbs. per hour at 406.7 HP. In the figures just given for the coal consumption the coal used to drive the independent vacuum pump is not included. The figures, therefore, represent what would have been obtained per indicated horse-power if the engine had driven the vacuum pump.



PARTIAL VIEW OF CONCRETE-STEEL BRIDGE SHOWING DETAILS OF RAILINGS AND FINISH.

The coal consumption forms a more accurate basis for comparing the efficiencies of engines using saturated and superheated steam than the heat consumption, because when the coal consumption is obtained it allows for any difference in the economy of the combined boiler and superheater from that of an ordinary boiler. In the present tests this difference amounted to 1.5% in 70, or about 2%, and if compared on the heat unit basis the difference in favor of the superheated steam tests would be too great by this amount.

In the test with saturated steam the coal consumption was about 19% greater than that obtained at the same power with superheated steam. This does not form a proper basis of comparison, however, for the two reasons already stated, which are that the engine was not built for saturated steam and that the vacuum in the test was not as high as it should have been. An engine of the same general type built for saturated steam, but of about twice the power, was tested by the writer and the results were embodied in a paper presented by him at the Saratoga meeting. The most economical heat consumption obtained was 222.7 B. T. U. per minute per horse-power. The vacuum in this case was exceptionally high, being over 28 ins. If the vacuum had been about 26 ins., as in the present tests, it is probable that the heat consumption would have been about 230 B. T. U. per minute per indicated horse-power, and the coal consumption on the basis already given 1.42 lbs. per hour per horse-power. As the minimum coal consumption with superheated steam was 1.257 lbs. per hour per horse-power there is a gain in favor of using superheated steam of .163 lbs. per hour per horse-power, or the larger steam engine using saturated steam is about 13% less economical than the smaller one using superheated steam.

TABLE I.—AVERAGE DATA AND RESULTS OF ENGINE TESTS.

Date of Test: 1903	May 27	June 19	July 17	July 24
Condition of Steam: superheated or saturated	Sup.	Sup.	Sup.	Sat.
Length of tests in hours and decimals of an hour	5.15	6.033	6.00	6.50
Water feed to boiler in pounds per hour, corrected for leakage	4,633	4,018	2,684	5,630
Average Pressures.				
Steam at boiler in pounds per square inch	147.0	147.9	148.5	149.3
Steam near throttle in pounds per square inch	141.2	142.4	145.6	145.1
Steam in receiver in pounds per square inch	21.9	17.6	5.6	20.8
Vacuum near engine in inches of mercury	25.11	25.82	26.32	24.47
Vacuum at condenser in inches of mercury	25.80	26.79	26.81	25.24
Barometric pressure in inches of mercury	30.16	29.80	30.01	30.00
Temperatures of Steam in Degrees Fahr.				
Leaving the superheater	766.4	808.0	849.0	.....
At the engine throttle	713.7	736.3	756.8	.....
Entering the high pressure cylinder	634.4	658.6	672.0	.....
Leaving the high pressure cylinder	346.5	331.5	287.7	262.0
Entering the low pressure cylinder	408.0	395.9	353.6	269.1
Leaving the low pressure cylinder	135.1	128.2	124.1	.....
Amount Steam was Superheated in Degrees Fahr.				
Leaving the superheater	402.4	443.4	384.1	.....
At the engine throttle	352.5	374.5	393.3	.....
Entering the high pressure cylinder	273.2	296.8	308.5	.....
Leaving the high pressure cylinder	84.7	77.0	52.0	.....
Entering the low pressure cylinder	146.2	141.4	117.9	7.1
Horse-power and Economy.				
Revolutions per minute	103.28	102.34	102.40	102.20
Indicated horse-power developed by the engine	474.5	420.4	276.8	406.7
Water consumption in pounds per hour per indicated horse-power	9.76	9.56	9.70	13.84
Maximum temperature to which the feed water could be heated by the exhaust of the engine*	133.5	125.1	121.7	148.4
Heat consumption in British Thermal Units per minute, corresponding to the heat in steam at the throttle valve, and the maximum temperature of feed water—Standard of the Civil Engineers of Great Britain	205.0	203.7	208.8	248.2
Heat imparted to the boiler and the superheater in British Thermal Units per pound of dry coal	9,725	9,725	9,725	9,947
Coal per hour per horse-power on basis of the heat consumption recommended as a standard by the Civil Engineers of Great Britain. In this the loss due to radiation of the steam pipe from the boiler to the engine is not charged against the engine, and it is credited with the maximum temperature at which it can return the feed water to the boiler	1.265	1.257	1.288	1.497
Actual water evaporated and superheated per pound of dry coal in test made June 19	.....	7.00	.....	.....
Actual coal burned per hour per indicated horse-power	.....	1.348	.....	.....

*In the fourth test, which was made with saturated steam, allowance is made for the heating effect of drip water drawn from the receiver, which amounted to 280 lbs. per hour.

METHODS OF CONDUCTING THE TESTS.—The water was weighed in an iron tank of about 1,000 lbs. capacity placed on a platform scale, and it was then emptied into a lower tank connected with the suction pipe of a geared boiler feed pump driven by the main engine. All steam and water connections, where there was a possibility of leakage occurring, were either broken or blanked off.

Indicators of the Star Brass Manufacturing Co., having outside springs, were used on the high pressure cylinder. Tabor indicators of the ordinary pattern were used on the low pressure cylinder. Mercury columns were used to measure the vacuum both in the exhaust pipe near the engine and near the condenser. A spring vacuum gage was also used near the condenser, which was calibrated in order to determine its correction. Mercury thermometers placed in thermometer wells were used for determining the temperatures. Where the temperatures were not too high mercury was used in the wells, and if the mercury evaporated, melted solder was employed. In every case the error due to exposing a portion of the stem of the thermometer was determined by noting the graduation to which it was immersed and estimating the temperature of exposed part of the mercury in the stem by tying a second thermometer against the stem.

Readings were taken at intervals of 15 minutes throughout the tests. The water record was balanced up at the end of each hour. The feed pump was kept running uniformly and was not stopped in balancing up the water. The engine was run for some time before starting each of the tests in order that the temperatures should become practically constant. The steam leakages were carefully estimated, and in one case a leakage test was made on the boiler and the results confirmed the amount which was estimated. The steam leaks amounted to 40 lbs. per hour as a maximum.

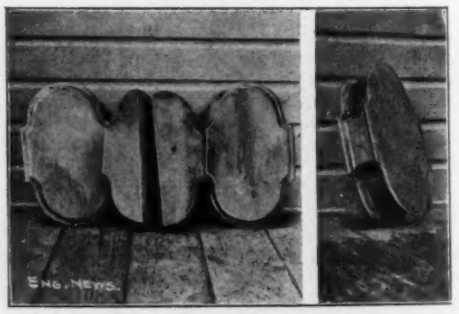
GRAPHICAL DETERMINATION OF ANGLES IN SKEW STRUCTURAL WORK.*

By C. G. Wrentmore.†

This is not a difficult problem. On the contrary, it is so simple that no draftsman with a working knowledge of descriptive geometry of the right line and plane should find the least trouble in it. However, since it is the writer's experience that the average draftsman lacks this knowledge, he takes the liberty of stating herein the application of a few first principles.

The problem has been very well solved by the method of spherical trigonometry in Engineering News of Feb. 15 and 22, 1900, by Mr. C. A. P. Turner, and, as a matter of convenience in comparison, Mr. Turner's nomenclature will be followed here. The angles which he works out are the following:

A = angle between plane of roof and a horizontal plane;
B = angle between the horizontal traces of the roof plane and the plane of hip web;
I = angle between the hip rafter and the horizontal plane;
P = angle in roof plane between a main rafter and hip rafter;
X = angle between a vertical line and the trace of the purlin web upon the hip web plane;
G = angle between the roof plane and the back of hip;
V = angle in purlin web between a normal to center line of purlin and the trace of hip web on purlin web;
M = complement of angle between purlin web and hip web;
D = angle in back of hip between a line normal to hip web and the trace of purlin web on back of hip;
F = complement of angle in purlin web between traces of hip web and back of hip;
E = angle between back of hip and purlin web.



Forms for Molding Bridge Railings.

In the above, by "back of hip," "hip web," and "purlin web," are meant "plane of back of hip," etc.

The sketch on page 29 shows two roofs in which horizontal lines run at right angles, and which have slopes shown by the angles A and A'. Four planes of projections are used, one a horizontal plane H, the other three vertical, one the vertical plane of the hip web and

*From the "Michigan Technic," 1903.

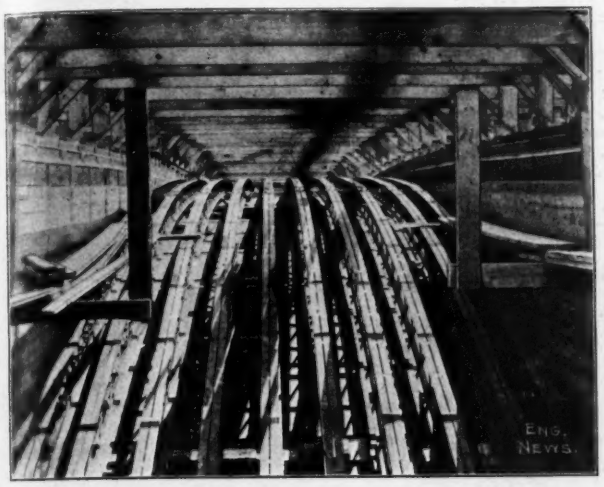
†Instructor in Descriptive Geometry and Drawing, University of Michigan, Ann Arbor, Mich.

the other two respectively perpendicular to the H traces of the roof planes.

We have therefore three ground lines, L N, C K and O Q. The vertical projection which is used for any particular solution is theoretically immaterial, but practically much time may be saved and much labor as well by choosing the correct one.

Angle A is given by the conditions of the problem. In many cases it is a quarter pitch roof, but may be anything from a horizontal to a vertical. In the sketch the angle A is quarter pitch and A' is third pitch.

Angle B: Assume any point K' in the roof line L K' at a height N K' above H, and find the point K''' in the other roof line at the same height, by making the length K''' Q = N K'. Project these points to the ground lines



INTERIOR VIEW OF ARCH FORMS SHOWING REINFORCING RIBS IN PLACE.

in N and Q and through these H projections draw parallels to the eave lines C O and C L, meeting at K. Then C K is the H projection of the hip, and L C K the angle B for one roof and O C K the angle B' for the other.

Angle I: At K erect the line K K'' normal to the ground line C K and equal to N K'. C K'' is the position of the hip revolved about C K into H, and is the trace of each of the roof planes upon the vertical plane C K. K C K'' is the angle I.

Angle P: Revolve the roof plane C L K' about its H trace C L into H, at the same time revolving the line of the hip. S S' is a point in the hip which revolves to the position S''. A main rafter is perpendicular to C L in revolved position and the hip lies at C S''. Therefore S'' C O is the value of P.

Angle X: The plane of the purlin is taken normal to the plane of the roof, its H trace being K N and its V trace N. R'. A line in this plane through R' parallel to K N lies in the roof plane and cuts the line of the hip at R R''. K R'' is the trace of the purlin on the V plane C K and R R'' is a vertical line in the same plane. R R'' K is therefore the value of the angle X.

Angle G: The roof plane and the back of the hip intersect in the line of the hip C K — C K''. The plane t T t' normal to this line, cuts the back of the hip in a line parallel to its H trace t T, and cuts the roof in a line which revolves about t T into H in the line t t''. The angle G is therefore the angle between t t'' and a line parallel to t T, or the angle T t t''.

Angle V: The intersection of hip and purlin webs is the line K R — K R''. Revolving this about the H trace of purlin web, K N, the point R R'' is found at r', and the line K R — K R'' takes the position K r'. R is revolved by swinging R' about the center N into N L and thence squaring across to the line R r' drawn perpendicular to K N. The angle R r' K is the required value of V.

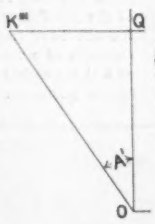
Angle M: A plane perpendicular to the intersection of purlin web and hip web, K R — K R'' is assumed at u U u'. This cuts from the purlin web a line which revolves into H trace at u u'' and from hip web a line which revolves into H in U u''. The angle between the planes is therefore shown at u u'' U and its complement at u'' u U, which is the angle M.

Angle D: The plane of back of hip is b C K''. It is cut by the purlin web in a line from R R'' to the intersection of the H traces b C and N K, the line being shown horizontally in R b and vertically in R'' C. When this is revolved about the H trace b C into H it falls at r'' b. A line normal to the hip web will revolve into H in a parallel to a C. The angle r'' b C is therefore the angle D required.

Angle F: The line R b revolved about K N into H falls at b r'. The revolved position of K R as already found is K r'. The angle between these lines, b r' K, is therefore the value of the complement of the angle F.

Angle E: The line of intersection of the two planes whose angle is required is R b. The horizontal projecting plane of this line is revolved about R b into H, the line R b — R'' C then falling at r b. A plane normal to both planes will have H trace g k, perpendicular to R b and its trace upon the horizontal projecting plane of R b is shown in revolved position at h m. If the plane g k be now revolved into H about g k as axis, the point in which it cuts the line R b — R'' C falls at n, and the angle between the planes is shown at g n k., which is the value of the angle E.

In work of this class where the greatest care must be exercised in detailing work to provide against the placing of two bodies in the same place at the same time, in the opinion of the writer there is less probability of error and greater probability of all clearances being provided for by the graphical method than by the method of computation. Some experience with skew work has led to the conclusion that where principal dimensions are checked by computation a drawing to quarter size will give all secondary dimensions with sufficient accuracy for all cases, both for angular and linear measurements. Drawings for this purpose, however, must be not only carefully, but accurately done, and the draftsman must know his own limitations in the matter of accurate work before he can determine how far his graphical solutions are trustworthy.



(The above graphical treatment of roof angles, together with the analytical treatment given by Mr. C. A. P. Turner, and referred to in the above, has been incorporated in modified form in the "Standard Data Sheets" of the Boston Bridge Works, Boston, Mass., for the use of their draftsmen, as we are informed by Mr. J. C. Moses, Chief Draftsman of the company. Three additional angles are included, namely:

N = Angle between center line of main rafter and trace of its web on back of hip.

K = Complement of angle between web of main rafter and back of hip.

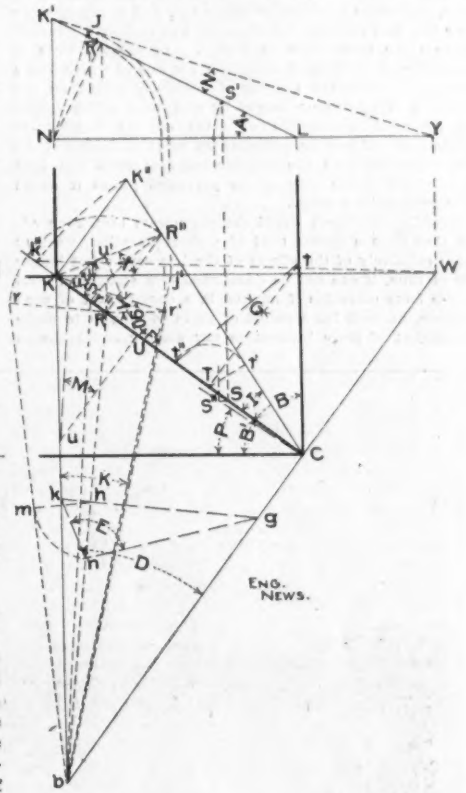
S = Angle between center line of hip and trace of main rafter web on back of hip.

The construction for these angles has been drawn in on the accompanying diagram. The procedure is as follows:

Angle N: The line K W is the H-trace of web of main rafter, and the line C W is the H-trace of plane of back of hip. Then the point W, Y, in H is one point in the intersection of the two planes; K, K' is another point. Hence, K W — K' Y is the line of intersection. The center line of main rafter is K Z — K' L. Since the required angle lies in the vertical plane, it is shown in true value by Y K' L.

Angle K: The intersection of web of main rafter and back of hip is already found to be the line K W — K' Y. A plane perpendicular to this line is b N J. Revolving this plane into H about b N, the point J j revolves to j', and the angle K j' b is the complement of the required angle K.

Angle S: The trace of web of main rafter on back of hip is already found to be the line K W — K' Y, and the center line of hip is the line K C — K' L. The required angle lies in the plane of back of hip, and its horizontal projection is C K W. Revolving about C W into H throws the point K to k''. Then the angle W k'' C is the required angle S.—Ed.)



THE PROTECTION OF STEEL FROM CORROSION.*

By Charles L. Norton.†

Since the publication of report No. IV., in which was given an account of some laboratory experiments which showed the great degree of protection afforded structural steel by Portland cement concrete, the experiments have been carried on continuously.

RESULTS.—All the early tests which were carried out on perfectly clean steel have now been repeated on specimens in all degrees of initial corrosion, with the same results as shown in the case of the chemically clean steel. Doubt existed in the minds of some engineers as to whether the results as found with clean steel would apply to rusty or dirty steel. The method adopted in the early test was to imbed the specimens in blocks of concrete about 3 × 3 × 8 ins., allow them to set under ordinary conditions and then expose them to changing conditions of warmth, moisture and to carbon dioxide, with traces of sulphurous gases and ammonia. Under these conditions unprotected steel vanished into a streak of rust, but protected by an inch or more of sound Portland cement concrete the clean steel was absolutely unchanged. We can now state further, that this same protection is afforded any ordinary structural steel of that degree of cleanliness likely to be found in use for building.

SPECIMENS.—The origin of many of the specimens was rather obscure, as the more corroded ones were taken from scrap heaps of steel works, many having been exposed to the weather for several years. Some had been in buildings as part of the structure, some in salt water, some in fresh water, some in damp ground, and the rest exposed to air under various conditions of dampness. The degree of rust on the specimens varied greatly, from a light yellowish stain to a scale more than one-eighth-inch in thickness.

PROCEDURE.—The specimens were first cut to a size that their length was not far from 3 ins. and their width about 1 in. They were of all thicknesses from 1-50 to 1¼-in. Some were cut dry, some in water, some with the mill fed with oil, and a part of these cut with oil were cleaned with gasoline, and a part with alkaline solutions, while a third part were left more or less oily. It was intended that the specimens should include everything met with in regular practice.

Each specimen was stamped and the blows of the steel stamp were sufficient to loosen any rust or scale that was not firmly attached, and a vigorous brushing with a soft wire brush removed any loose dirt. Each piece was next weighed, and then calipered at several points, and incorporated in a block, or brick, of concrete, sufficiently large to cover it everywhere to a depth of 1½ ins. The mixture was 1 part cement, 2½ parts parts sand, and 5 parts broken stone in some cases, and 1 part cement, 3 parts sand, and 6 parts cinders in others. The cements used were Alpha, Lehigh and Alsen, and care was taken in selecting the sand and stone. The latter was of such size as to pass a 1-in. mesh. The concretes were allowed to set 24 hours in air and 7 days in water, and were then divided into three groups, one being set out-of-doors, one stored in a damp and odorous basement underground, and the third being treated in the "corroders" or steam and carbon dioxide tanks. These galvanized iron tanks were supplied intermittently with steam, hot water, moist air, dry air and quite continuously with carbon dioxide for periods of from one to three months. There were a number of specimens which were further exposed in tide water, in sewers, over furnaces, with constant contact of furnace gases.

*Extract from Report No. IX. of the Insurance Engineering Experiment Station. Report No. IV. was abstracted in Engineering News, Oct. 23, 1902.

†Expert in charge of Insurance Engineering Experiment Station, 31 Milk St., Boston, Mass.

CONDITION OF SPECIMENS.—After varying lapses of time from one to three months for the specimens in the "corroders," and from one to nine months for the others, the specimens were broken out of the briquettes, cleaned by brushing, and weighed and calipered. Not one specimen had shown any sensible change in weight or dimension, except where the concrete had been poorly applied. Some specimens were purposely bedded in very dry concrete, and some in concrete partly set, and many of these were not well covered and the steel was seriously attacked where there were voids or cracks. Of the hundreds of specimens of rusty steel examined, not one of which had a continuous unbroken coating of concrete, gained or lost anything in volume or weight by treatment which caused the practical destruction of some of the unprotected specimens. If loss by corrosion as great as 1-1000 of the loss occurring with the unprotected specimens had been experienced in the case of the protected pieces it would have readily been noted.

CONCLUSIONS.—It would therefore seem that if we admit that from a severe trial of a short duration, we may judge relatively of the effects of the less severe but longer test of time, it can not be questioned that structural steel is safe from corrosion if incased in a sound sheet of good concrete, at least for a period of years so long as to make the subject of more interest to our great-grandchildren's children than to us. We know that bare steel does not rust and fall down over night, and that much of the steel standing has been bare of everything that could protect it, for long years, and it seems to me beyond question that steel properly covered in concrete may well be expected to last far longer than the changes in our cities will allow any building to remain.

There is one limitation to the whole question, that is the possibility of getting the steel properly incased in concrete. Many engineers will have nothing to do with concrete because of the difficulty in getting "sound" work. This is especially true of cinder concrete, where the porous nature of the cinders has led to much dry concrete and many voids, and much corrosion. I feel that nothing in this whole subject has been more misunderstood than the action of cinder-concrete. We usually hear that it contains much sulphur and this causes corrosion. Sulphur might, if present, were it not for the presence of the strongly alkaline cement; but with that present the corrosion of steel by the sulphur of cinders in a sound Portland concrete is the veriest myth, and as a matter of fact the ordinary cinders, classed as steam cinders, contain only a very small amount of sulphur. There can be no question that cinder-concrete has rusted great quantities of steel, but not because of its sulphur, but because it was mixed too dry, through the action of the cinders in absorbing moisture, and that it contained, therefore, voids; and, secondly, because in addition the cinders often contain oxide of iron which, when not coated over with the cement by thorough wet mixing, causes the rusting of any steel which it touches.

There is one cure and only one, MIX WET AND MIX WELL. With this precaution I would trust cinder concrete quite as quickly as stone concrete in the matter of corrosion. It has been suggested that steel which has been rusted to a slight depth becomes protected by this coating from further rusting. Nothing could be further from the truth. A large number of specimens were rusted by repeated alternate wetting and drying to see if they finally reached a constant condition. Instead of doing this, they all showed an irregular but persistent loss in weight, on further rusting, until some had practically been washed away.

The increasing use of steel of small dimensions in floors and roofs, twisted rods, expanded metal, etc., has caused some question as to the advisability of their use in view of the possible great effects of corrosion, as compared with the effects of corrosion on larger members, but with sound concrete of a thickness of about 1½ ins. between the steel and the weather I do not question the durability of these lighter members.

The destruction caused to steel work by rust is certainly not more appalling in most instances, at least, than that caused by electrolysis. The action here is more apt to be local, and hence more dangerous in that inspection or protection of other parts of a structure will not indicate or prevent impending disaster to the one member which may serve as the point of departure of the escaping electric current. No satisfactory treatment other than some sort of waterproofing has appeared to be successful, and study of this matter is going on at present in many placed. It is a problem for the chemist rather than for the engineer.

The next step in this research is to find out in the same general way the degree of protection afforded by paint, and second, by brick and tile work. This is now under way and the rapidity with which the "corroders" destroy some paints is such that a report on this subject may be looked for in the near future.

The investigation of the relative efficiency of different paints as a protective coating for structural steel being now under way. It is desired that all kinds of paint be submitted to our test of exposure to varying conditions. To this end we invite all dealers and manufacturers of paints, for this purpose, to send samples to the amount of one gallon to Prof. C. L. Norton, Room A, Walker Bldg., Massachusetts Institute of Technology, with any directions for applying the paints to either clean or ordinary rusty steel. The results of these tests will not be published without the consent of the persons submitting the paint to test.

Some pieces of steel will, after coating with the paint under test, be submitted to various corrosive influences, and the details of the exposure being such as will correspond in nature to the actual exposure of structural steel, but of an intensified degree, it is believed that relative results may be arrived at in a reasonably short time in this way.

BRICK MAKING PLANT OF THE WESTERN BRICK CO., DANVILLE, ILL.

The plant of the Western Brick Co., at Danville, Ill., is notable for three particular reasons: (1) The character of the raw material and fuel supply; (2) the use of the hydraulic process for stripping; and (3) the utilization of waste heat from the kilns for heating the drying room. The construction of these works was commenced in November, 1900, and the manufacture of building and paving brick was commenced in April, 1901.

FIG. 1. STRIPPING AND EXCAVATING SHALE WITH STEAM SHOVELS AT THE WESTERN BRICK CO.'S WORKS, DANVILLE, ILL.
The steam shovel on the upper bench is stripping the overburden. The steam shovel on the lower bench is excavating the shale.

The plant was originally designed for a capacity of 100,000 brick per day, but in 1902 this was increased to 200,000, and about 300 men are now employed. The plant was designed by Mr. F. W. Butterworth, General Manager, to whom we are indebted for information furnished during a recent visit to the works.

The company owns about 175 acres of land a few miles from the city, and the site is peculiarly advantageous in that the deep bed of shale is underlaid by a 6-ft. vein of coal of excellent quality for the kilns. The main bed of shale is 20 to 75 ft. thick, covered with an "overburden" of clay and gravel which is 3 ft. to 38 ft. thick. Under the shale is the Danville vein of coal, 6 ft. thick, followed by 3 ft. of fireclay and 15 to 25 ft. of shale, but both the fireclay and this second bed of shale are said to be practically useless. Then comes a second vein of coal (the Grape Creek vein), 2 to 10 ft. thick, below which is a bed of good shale of unknown depth, into which test pits have been sunk for 250 ft. The present workings are in the upper bed of shale and Danville

vein of coal. The land constitutes high ground along the Vermillion River, broken by deep ravines, and as the bottom of the workings in the first coal vein is about 30 ft. above the river there is excellent natural drainage, which avoids the necessity of pumping out the pits.

Two pits are now being worked, and the character of the shale varies at different depths, the upper part being used for making paving brick, and the lower part for building brick. Analyses of these shales show the following results:

	Paving brick, shale.	Building brick, shale.
Clay base and sand	85.20%	75.99%
Fluxes	8.85%	14.22%
Combined water	6.16%	7.84%
Moisture at 100° C.	1.15%	1.70%

Before the shale can be excavated there is necessary the stripping, or removal of the "overburden" or surface covering of clay and gravel, which is from 3 ft. to 35 ft. thick. This was at first done by steam shovels, loading small dump cars hauled by locomotives, as shown in Fig. 1, where the upper shovel is excavating or stripping the overburden, while the lower one is excavating the shale. Later, however, the method of "hydraulicing," or washing away the material by powerful jets of water was adopted, with the result that in a depth of 5 to 10 ft. the material was removed at a cost of 3 cts. per cu. yd. For this purpose a Stilwell-Bierce duplex pump with a capacity of 3,000,000 gallons per 24 hours was installed on the river bank, and a 10-in. main carried up the bluff and across the top of the work to the point to be cleaned. Two branches were then laid, each ending in a 2½-in. "giant" or nozzle, counterbalanced by a box of stones so that the man could easily handle and direct it. The displaced material is washed into flumes and carried down to the flats or bottom lands, where much of the debris is deposited, while the water runs off into the river. The pressure at the nozzles is about 125 lbs.. Enough surface is cleared before winter to enable the steam shovels to work to their full capacity until the spring, when the hydraulic stripping can be resumed. Fig. 2 shows this work in progress.

As the coal is exposed by the excavation of the shale it is easily worked. Light shots are exploded at some distance back from the face so as to loosen it, and the 6-ft. face of coal is excavated by pick and shovel, the coal being loaded into wagons.

For excavating the shale, two steam shovels are employed, one in each pit. One of these is a Bucyrus 2½-yd. machine, but fitted with a 1½-yd. dipper. The other is a Marion machine, with a 1½-yd. dipper. The shale is loaded into Peteler wooden side-dump cars of 3 cu. yds. capacity, running on light tracks of 3-ft. gage, and hauled by two of the H. K. Porter Co's locomotives from the shovel to the foot of a rope incline of 25% grade, which appears in the background of Fig. 1. Two cars at a time are hauled up this incline by a Lidgerwood power drum, and run directly into the mill. The pit plant is shown in Fig. 3.

A general plan of the brick works is shown in Fig. 4. The shale dumped from the cars goes direct to a set of six 9-ft. dry pans, and then passes down inclined screens before going to two pug mills, in which it is tempered by the addition of the necessary proportion of water. A "soft-mud" machine, built by L. & A. Potts & Co., of Indianapolis, Ind., is used for making face brick, but the bulk of the output is made by two brick machines built by the Chambers Bros. Co., of Philadelphia, Pa., each having a capacity of 85,000 brick per day. One of these makes paving brick, and the other makes building brick. Each of these machines delivers a bar of clay about 15 ft. long, 9¼ × 4⅝ ins. in section, and this passes through a wheel having wire spokes which cut the bar into blocks or bricks. The speed of the wheel is regulated by the weight of the clay bar by means of a friction device, and the wheel is set at such an angle to the bar as to ensure a straight cut by the revolving wheel across the moving bar. The paving bricks are passed through four repressing machines, which consolidate them under a pressure of 15 tons per sq. in. The company's name is here branded on in raised letters, which thus serve to keep the brick apart in the pavement to allow of the requisite grouting. At the building-brick machine, a sand hopper delivers a film of sand around the bar of clay, partly on account of the color, but principally to prevent sticking.

The bricks delivered from the machines and represses are stacked on iron trucks ready for the drying house or oven. These run on tracks of 24 ins. gage. There are two tracks running between the pressing floor and the ovens, connected by turntables with lateral tracks on the pressing floor and extending into the ovens. The track next to the ovens is used for the loaded cars, while empty cars are returned to the pressing floor on the other track.

The necessary tempering with water to make the clay plastic enough to be worked requires the addition of about 1½ lbs. of water to each brick, but this water is only needed for about 10 minutes, after which about 36 hours are required to remove it, some 300,000 lbs. of water having to be evaporated in the drying house every 24 hours.

The drying house has 38 tracks 125 ft. long, with a drop of 20 ins. from the receiving to the delivering end. The temperature at the receiving end is about 125° F., and increases to about 212° F. at the delivering end. From 36 to 48 hours are consumed in this house, the slow movement and gradual increase in temperature being necessary to allow the bricks to be thoroughly warmed and dried from the inside. The circulation in the drying house is effected by two exhaust fans, which draw off the moist air through gratings at the bottom of the ovens. One of the special features of the plant is the use of waste heat from the kilns to heat the drying house, as noted below. After being dried, the bricks are run to the kilns to be burned.

Fig. 5 shows the brick mill and the kilns and stacks under construction. There are 50 circular down-draft kilns, 28 ft. in diameter and 7 ft. high, each holding 75,000 bricks. These must be stacked by hand and again loaded on the trucks for removal after burning, as no mechanical device has yet been perfected for handling brick which have so great a shrinkage as occurs in western clays. This shrinkage amounts to 1½ ins. in the length of the brick. Each kiln is heated by a number of coal fires in fireholes around the circumference, while the heated air is drawn down through the stacked brick into a system of conduits and thence discharged into the air through brick chimneys. This portion of the heat is wasted, the "continuous-burning" system not having yet been introduced in this country. About ten days are required for burning, a temperature of about 2,000° F. being maintained, and the end of the process being determined by measuring the shrinkage of the stack of brick through a hole in the top of the kiln.

During the burning there is driven off the mechanically and chemically combined moisture, and the color of the brick may be varied from light salmon to dark chocolate color by the oxidation of the iron in the clay, according to whether a reducing or oxidizing flame is used. Both paving and building bricks are burned in the same kilns, the latter being stacked at the bottom where the heat is less intense, but owing to the high percentage of the fluxes (as shown by the analyses already given), they become thoroughly vitrified, probably 90% of the output having an absorption of less than 2%.

After the brick have been thoroughly burned, which requires about ten days, the kiln is kept at a temperature of about 1,800° for five days, and is then cooled off. Ordinarily the heat given off in cooling is all wasted, but at these works the heat is utilized and the cooling hastened by drawing cold air through the kiln, the air thus heated being then delivered to the drying room. This is effected by underground conduits, with connections to each kiln, and the air current is formed by a 320-in. fan of the New York Blower Co.'s make, directly connected to an engine of 80 HP., with cylinders 16 × 20 ins., built by the Frost Mfg. Co., of Galesburg, Ill. From the fan the hot air is delivered into a conduit leading to the drying room. To prepare for cooling, a hole is knocked in the bricked-up doorway of the kiln, and a 30-in. sheet iron pipe inserted, the pipe having an elbow which enters a manhole in the top of the conduit, leading to the main collecting duct, which is 6 × 7 ft., 740 ft. long. The cooling takes about seven days, making about 24 days in all, including the filling and emptying of the kiln.

Two pairs of depressed tracks are provided for loading railway cars, being so arranged that cars on one track can be loaded directly from the kiln, while those on the other track can be loaded from storage. The tracks have sufficient capacity for 60 cars. Large sheds are used for storing the building brick, but the vitrified paving brick is stacked in the open air.

FIG. 2. HYDRAULIC EXCAVATION FOR STRIPPING SHALE BEDS.

FIG. 3. SHALE PIT PLANT.

The power for the dry pans, brick machines, pug mills and presses is furnished by a Corliss engine of 475 HP., with cylinders 24 x 48 ins., steam for which is supplied by five tubular boilers of 125 HP. each. There is also a direct-connected generator supplying electric current for lighting, and also for some small power purposes.

A special feature of the company's product, in addition to its paving brick, is an impervious, vitrified building brick of great strength, from which dirt and smoke will be washed by rain. This class of brick is being largely used for railway stations, etc., and has been used for the exterior of the buildings of the new plant of the Milwaukee Gas Co., the Chicago & Eastern Illinois Ry. shops, etc.. Tests of the ordinary building brick, made at the University of Illinois are noted below:

TESTS FOR BUILDING BRICK, MADE FOR WESTERN BRICK CO.

Cross-Breaking Test.

Breadth, ins.	Depth, ins.	Breaking load, ins.	Modulus of rupture.
2.3	3.87	14,450	3,770
2.3	3.87	11,800	3,080
2.25	3.8	12,000	3,330
2.3	3.8	10,500	2,840
2.4	3.9	12,000	2,960
2.4	3.8	14,300	3,710
2.3	3.8	13,600	3,680
2.35	3.8	15,400	4,080

Span, 6 ins. Bearing plates were used. Each brick broke near the center.

Crushing Test.

Dimensions Length.	Width.	Area, sq. ins.	Load, lbs.	Crush. str'gth, lbs. pr sq.in.
2.75	3.87	10.6	162,000	15 300
2.68	3.86	10.35	143.500	13,850
2.2	3.84	8.45	150,700	17,830
2.2	3.86	8.5	102,000	12,000
2.57	3.90	10.0	194,700	19,470

Thin coats of plaster of paris were used to distribute the pressure.

The bricks broke suddenly and formed little columns. Average Sc., 15,690.

Absorption Test.

Weight Dry.	Wet.	Water absorbed Weight.	Pr ct.	Weight Dry.	Wet.	Water absorbed Weight.	Pr ct.
1.42	1.425	0.005	0.35	1.495	1.50	0.005	0.34
1.40	1.40	0.0	0.00	2.34	2.395	0.033	1.27
1.495	1.51	0.015	1.00				

Time immersed, 48 hrs. The bricks were thoroughly dried before immersing. Average per cent. absorbed is 0.592.

Correct, R. H. Slocum.
Approved, Arthur N. Talbot.

Urbana, Ill., April 14, 1903.

We give below two reports by Prof. A. N. Talbot, of the University of Illinois, one referring to the above tests of building brick and the other to some tests of paving brick:

BUILDING BRICK.—The results of the tests on your building brick (shown above) are remarkably good. The brick are unusually strong, as shown by both cross breaking and compression tests, and the absorption of water is even lower than the strictest requirements for paving brick. Brick of this grade will stand the very heaviest loads. They rank with the very best brick we have tested.

PAVING BRICK.—The paving brick tested are of excellent quality. The texture is even, close-grained and uniform throughout the whole brick. The brick are strong and will stand high pressure, as is shown by the high modulus of rupture in the test of transverse strength. The absorption test is low. The rattler test shows an unusually good quality of paving brick, the results comparing favorably with the best brick tested here. Altogether the tests show a superior quality of paving brick. Brick of this grade will make a very satisfactory pavement.

AN EXAMPLE OF THIN MACADAM ROAD CONSTRUCTION ALONG THE CHARLES RIVER, MASS.

By J. Albert Holmes.*

The Parkway along the Cambridge shore of Charles River is constructed on filled land for nearly its entire length of about four miles. The Charles is a tidal stream. The areas filled were salt marsh lands lying at an elevation of about high tide and mud flats slightly above low tide. Mean high tide in Boston Harbor reaches an elevation of 9.6 ft. above m. l. w., and often in times of storm reaches a point two or three feet higher. The elevation of streets along the Cambridge River front is fixed at 15.38 ft. above m. l. w.; this elevation was adopted for the center line of the driveway. It was thought that a surfacing of gravel would answer all purposes until such time as the Parkway was fully completed and nearly all settlement had taken place.

A section 1,300 ft. in length was surfaced in 1900 with a foot of good binding gravel and rolled with a steam roller. The soft material under this portion of the driveway averaged 20 ft. in depth; the process of filling had extended over a number of years, and considerable settlement had occurred. The final fill was carried 1 ft. above grade to provide for future settlement.

During the fall and winter of 1901-1902 a large amount of extra travel was turned onto this portion of the driveway because of the closing for repairs of one of the bridges over the Charles. The

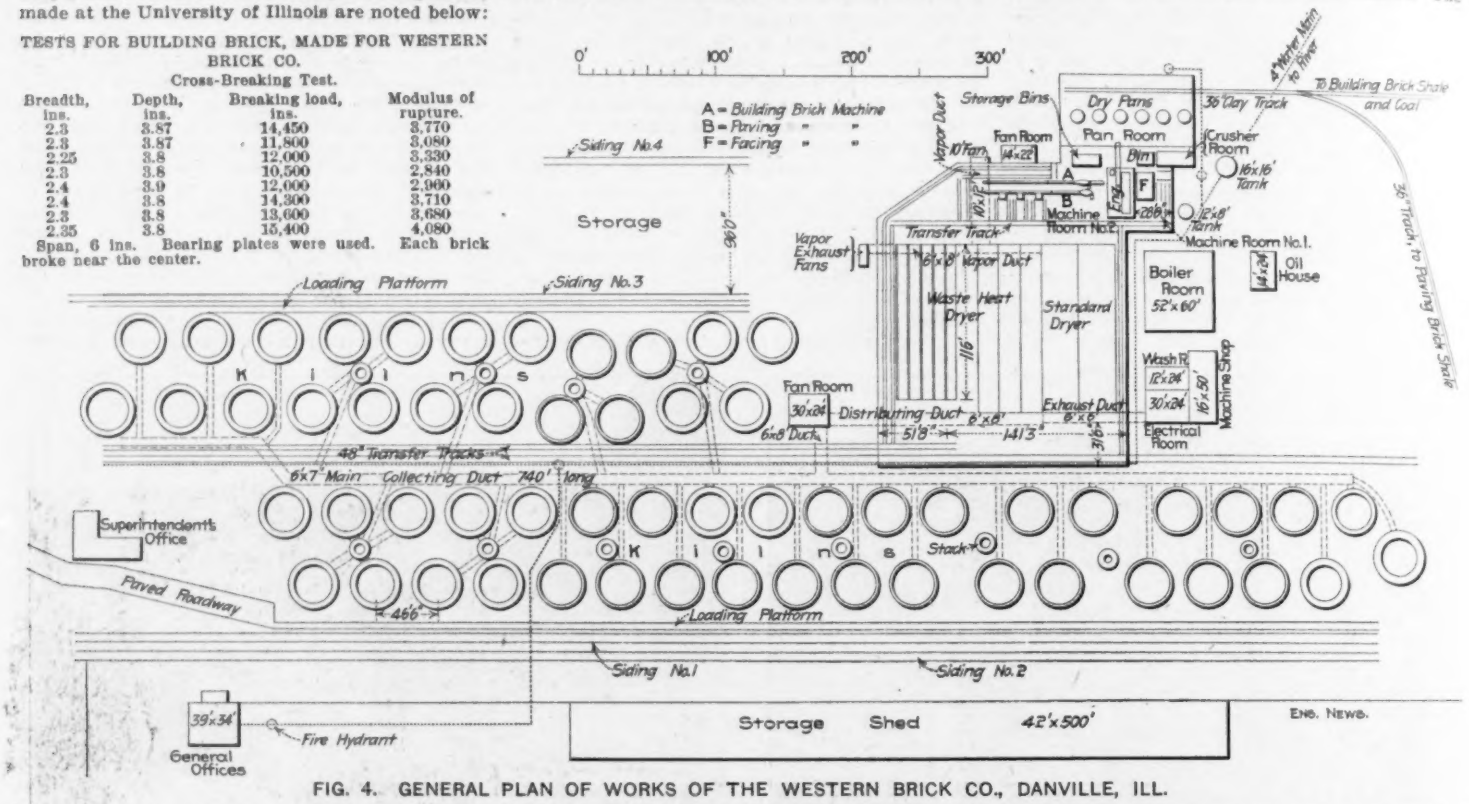


FIG. 4. GENERAL PLAN OF WORKS OF THE WESTERN BRICK CO., DANVILLE, ILL.

the driveway, which is level its entire length with one or two exceptions.

This fixed elevation necessitated an original fill on the marsh of 6 ft., and on the mud flats of about 15 ft. The depth of the underlying soft material varied from 1 to 30 ft. Considerable settlement and displacement occurred during the operation of filling, and for this reason it was not considered wise to place a permanent surface on the driveway, which is level its entire length with one or two exceptions.

This fixed elevation necessitated an original fill on the marsh of 6 ft., and on the mud flats of about 15 ft. The depth of the underlying soft material varied from 1 to 30 ft. Considerable settlement and displacement occurred during the operation of filling, and for this reason it was not considered wise to place a permanent surface on gravel surfacing was badly worn as a result. It was decided in the spring of 1902 to place a macadam surface on this section of the road. For reasons of economy, it was proposed to make the macadam 4 ins. thick at the center and 2 ins. at the sides.

It was found upon leveling over the driveway that it had settled an average of 13 ins. It had now reached a point 1 in. below its proposed grade, but still retained its original form, making an excellent subgrade to receive the macadam.

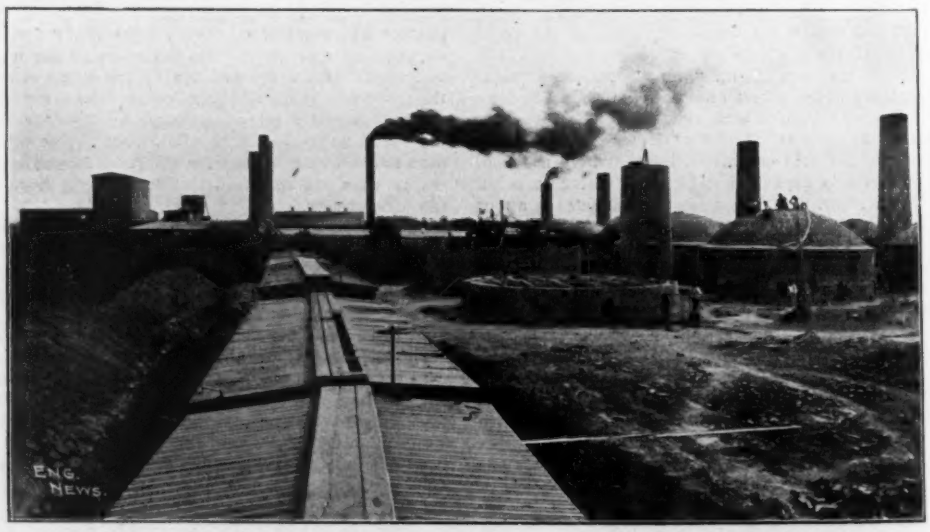


FIG. 5. BRICK MILL, WITH KILNS AND STACKS UNDER CONSTRUCTION.

*Member Engineering Staff, Charles River Basin Commission, 57 Adams St., Somerville, Mass.

The driveway is 40 ft. in width, but only 30 ft. of this width was surfaced, leaving 5 ft. gravel strips on either edge. (See Fig. 1.)

It will be noticed by reference to the plan that catchbasins are placed at intervals of 200 ft. The center line of the driveway is level. Sufficient slope is gotten in the gutters for drainage by making crowns halfway between each set of catchbasins.

The elevation of the center line of macadam was raised 3 ins. above the fixed grade for the driveway, thus providing the necessary 4 ins. without removing or disturbing the well compacted gravel.

Three cross-sections were calculated after the formula given in Eng. News, Mar. 6, 1902, p. 194. It will be seen that these three sections are repeated twice in every 200-ft. strip over the entire length of the driveway.

The macadam was placed in two layers, the bottom course when rolled to be 3 ins. thick, the top course 1 in.

The broken stone was gaged as follows:

Size of screen openings.	3-16-in.	¾-in.	1½ ins.	2½ ins.
No. of product.....	4	3	2	1

The bottom course 20 ft. in width consisted of No. 1 stone, the top course consisted of a mixture of Nos. 2 and 3 was 30 ft. wide, and overlapped the bottom course 5 ft. on either side. No. 4 was the binder.

To determine the depth of loose stone to be placed, it was assumed that it would roll down to 62% of its original depth. This was found to be the case in some 6-in. macadam laid at Newton, Mass., in 1897, on which measurements were taken. Sufficient rolling could not be given the macadam to compact it to the extent calculated. The quantities were changed and 33% was allowed for compacting, making the thickness 67% of the original depth, this being the rule followed by the Massachusetts Highway Commission. Under the rolling given, however, it was compacted to but 85% of its original depth. The rolling was done with three different steam rollers, varying from 12 to 15 tons, the lightest weight roller giving best results.

The thickness of finished macadam was determined by placing pieces of canvas about 12 ins. square on the subgrade, and afterwards making small holes in the macadam over the canvas and measuring the thickness.

The driveway was rerolled in the spring of 1903. Nothing further in the way of repairs has been done, and after a year and a half of service it is in excellent condition.

On a nearby street, at about the same time the park road was surfaced, macadam was placed in a single layer, using 2½-in. stone with a binder of dust. The binder soon wore away and now the large stones are exposed over the entire surface of the street.

In Fig. 2 are shown sections and details of catch-basins and gratings used. Where the driveway is carried a distance back from the river, the surface water from several basins is collected and discharged through one outlet or turned into some convenient storm sewer.

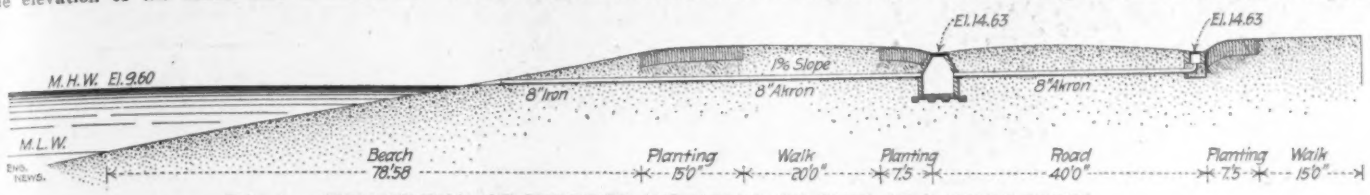


FIG. 1. CROSS-SECTION OF DRIVEWAY AND WALKS ON BANK OF CHARLES RIVER.
Cambridge Park Commission.

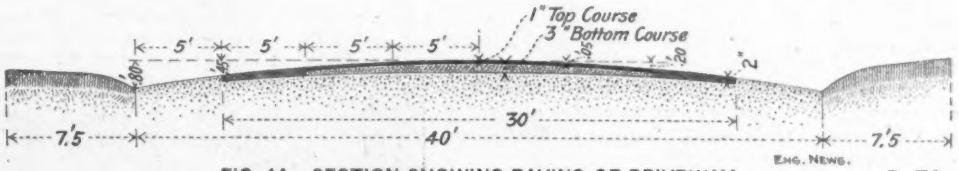


FIG. 1A. SECTION SHOWING PAVING OF DRIVEWAY.

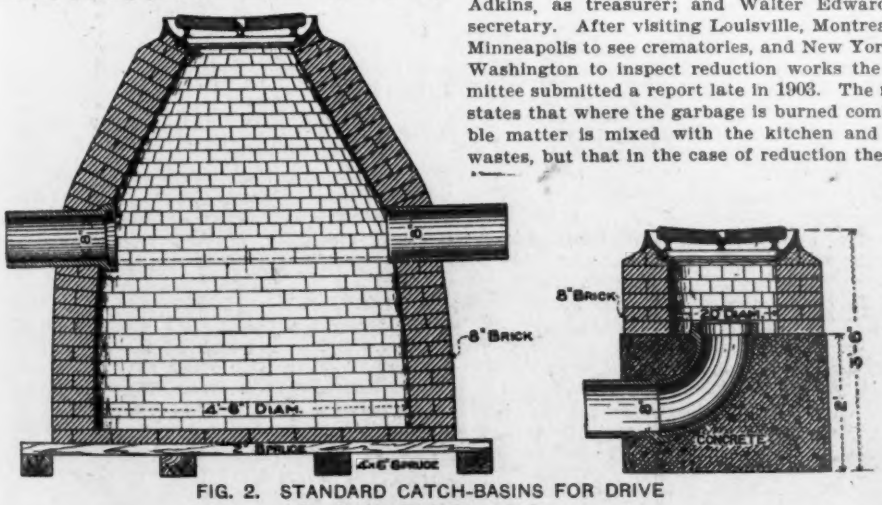


FIG. 2. STANDARD CATCH-BASINS FOR DRIVE
Cambridge Park Commission.

REPORT ON GARBAGE COLLECTION AND DISPOSAL AT ST. LOUIS, MO.

The future of garbage disposal at St. Louis is very uncertain. The contract with the St. Louis Sanitary Co. for disposal was to expire in November, 1904, and the contract with the Excelsior Hauling & Transfer Co. was to run until July 15, 1908, but recently the State Supreme Court, in passing on the conviction of Edward Butler for attempted bribery as a means of securing the disposal contract, held that the contract was illegal because the Board of Health had no authority to act for the city in awarding the contract. The same principle would also annul the contract for collection. On the strength of the ruling the city has refused to make further payments under the contracts.

A few months ago the municipal assembly of St. Louis appointed a committee of city officials to report on garbage collection and disposal. The commission organized by electing Mr. Hiram Phillips, M. Am. Soc. C. E., as chairman; Mr. Ben. C. Adkins, as treasurer; and Walter Edwards, as secretary. After visiting Louisville, Montreal and Minneapolis to see crematories, and New York and Washington to inspect reduction works the committee submitted a report late in 1903. The report states that where the garbage is burned combustible matter is mixed with the kitchen and table wastes, but that in the case of reduction the combustible wastes are excluded. In none of the places having furnaces was more than one-third of the garbage of the city burned, while at Louisville the furnace had been closed, on account of the long haul to reach it, and all the garbage was being dumped.

In Minneapolis, Louisville and Montreal garbage collections are made by the respective cities. In Minneapolis the board of health, and in Louisville and Montreal the street cleaning departments have charge of garbage collection and disposal.

In New York garbage is collected separately by the street cleaning department and delivered by that department to the scows at the docks. The scows are towed to the reduction works by the contractor who operates the latter.

At Washington both collection and disposal are performed under one contract, supervised by the street cleaning department. Dead animals are included. The garbage is transported from the city to the reduction works by rail.

The committee states that the chief item of expense in garbage disposal is haulage. It gives the following figures for collection and disposal:

Louisville: (Collection and dumping?—Ed.) 48 cts. per cart load, estimated at ⅝ to ¾ of a ton per load.
Washington: Collection, hauling and final disposition, $1.258 per ton.
Minneapolis: Collection and incineration, $1.791 per ton.
Montreal: Collection and incineration, $2 per ton.
St. Louis: Collection, $1.6948 per ton; disposal, $1.732 per ton; total cost, $3.3268 per ton.

The eleven conclusions submitted by the committee, with recommendation for early action, were as follows:

(1) That final disposition of garbage can be most desirably and economically made by reduction and utilization.

(2) That it is most satisfactory to have the work of reducing garbage done outside the city limits.

(3) That it is not desirable for the city to own or operate a reduction plant because of putting the city into competition with private mercantile enterprises, and therefore reduction should be by contract with private parties.

(4) That neither competition nor lowest prices can be secured for a short term contract for the disposal of garbage, therefore it is best for the interests of the city that the contract be for a long time, and, in the opinion of your commission, the term should not be less than 15 years.

(5) That in order to shorten the haul it is desirable to establish receiving stations at various points in the city.

(6) That at the expiration of the present contract for the collection of garbage the city can be prepared to collect and haul the garbage with its own force.

(7) That in view of the increasing amount of wastes other than garbage or kitchen refuse, which is allowed to accumulate and become beds for the breeding of disease, as well as being filthy and unsightly, the city should take up and provide for the collection of and disposal of these wastes in a sanitary manner.

(8) That the best method of disposing of these wastes, or, as may be better termed, rubbish, is by burning, and for this purpose your commission believes that the city should establish two furnaces or incinerators in different parts of the city, thereby making the haul, the chief item of expense in handling wastes of this nature, as short as possible.

(9) That these furnaces or incinerators should be owned and operated by the city.

(10) That primary separation of garbage from rubbish and ashes and other materials should be required of householders and this requirement enforced.

(11) That the collection of these wastes should be made by the city with its own force.

We are informed by Mr. Phillips that an ordinance embodying the recommendations of the committee was pending in the municipal assembly on Dec. 28.

A ROLLING MILL DIRECTLY DRIVEN BY ELECTRIC MOTORS.

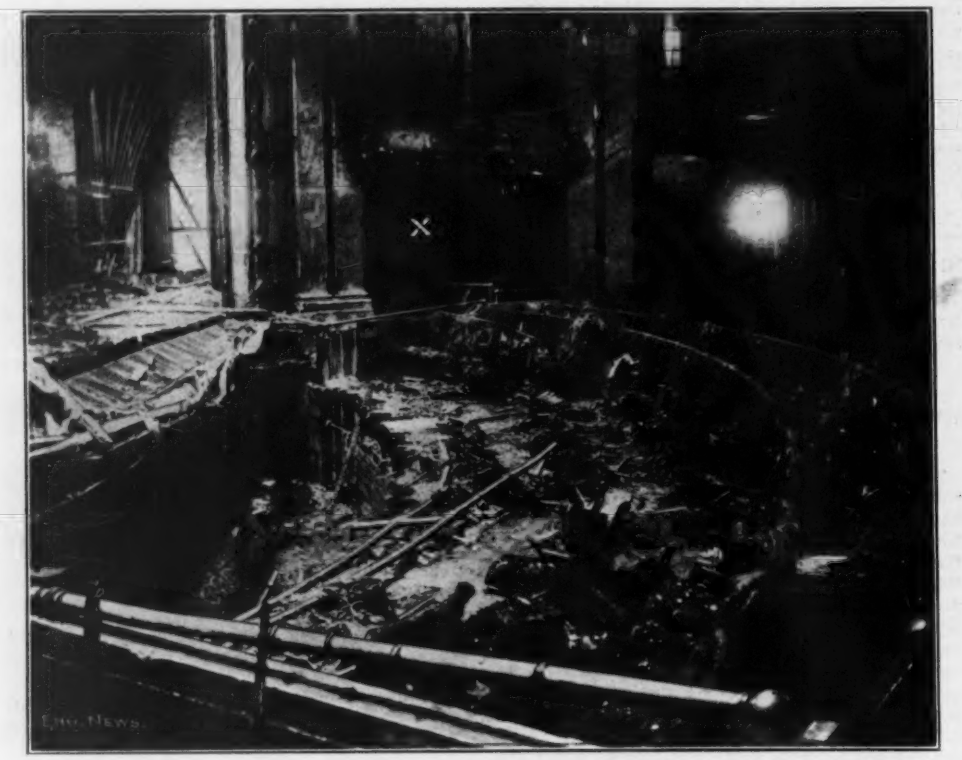
An interesting driving arrangement is used in a German rolling mill which was put into service a few months ago. The mill is driven by electric motors direct coupled to the roll-trains, one motor to each train. Current is supplied from the public mains of the local electric company. This supply is alternating current, of 5,800 volts at 50 cycles per second. In determining the manner of utilizing this current supply, three governing conditions had to be kept in view:

(1) The operation of the roll-trains must be independent, that is, the speed or load of one train must not affect the other trains; (2) The speed of each train must be capable of variation to suit the material being rolled; and (3) The fluctuations in the current drawn from the mains must be kept down to the minimum. The last condition was imposed by the supply company, as an obviously necessary protection to its service.

These conditions were met by the following arrangement: The alternating current from the supply mains is transformed to continuous current by means of a single motor-generator set; to equalize the load fluctuations a heavy flywheel is mounted on the shaft common to motor and generator. Each of the three roll-trains has direct-connected to its main shaft a direct-current motor of suitable power and high capacity for momentary overloads; in addition, a heavy flywheel is mounted on each roll shaft. The three motors are supplied from the direct-current side of the motor-generator set.

The general dimensions of this installation are as follows: The alternating-current side of the motor-generator set consists of an induction motor of 600 HP., operating with 5,800-volt 50-cycle current, and with a synchronous speed of 375 r. p. m. The generator side is a direct-current dynamo of 500 KW. normal capacity and 1,000 KW. overload capacity, producing current at 510 volts. The dynamo is compound wound, to run at 300-365 r. p. m. The flywheel, mounted between motor and generator, weighs 20 tons; it absorbs 16,000 HP.-seconds while the speed rises from 300 to 365 r. p. m. The blooming mill, which has 18-in. rolls and produces 8 × 8-in blooms, is fitted with a compound-wound motor of 200 HP. normal and 600 HP. overload capacity, taking current at 500 volts and running at 60 to 110 r. p. m. The flywheel, mounted between motor and rolls, weighs 12 tons. The roughing mill has 14-in. rolls; it is driven by a compound-wound motor of 200 HP. normal and 600 HP. overload capacity, running at 150 to 230 r. p. m., with current at 500 volts; its flywheel weighs 8 tons. The finishing mill with 10-in. rolls, is fitted with a compound-wound motor of 300 HP. normal and 900 HP. overload capacity, running at 320 to 460 r. p. m., with 500-volt current. The flywheel on this mill weighs 5 tons.

A short article in a recent number of "Stahl und Eisen," from which we take the above data, states that the arrangement perfectly equalizes the load fluctuations, drawing a constant power from the supply mains. The mean power consumption is 250 to 450 KW., depending upon the work being rolled. The installation described is in the rolling mill of the Bethlen-Falva Iron & Steel Works, in Upper Silesia, Germany.



FRONT OF ORCHESTRA AND STAGE OF IROQUOIS THEATER, CHICAGO, AFTER FIRE OF DEC. 30.

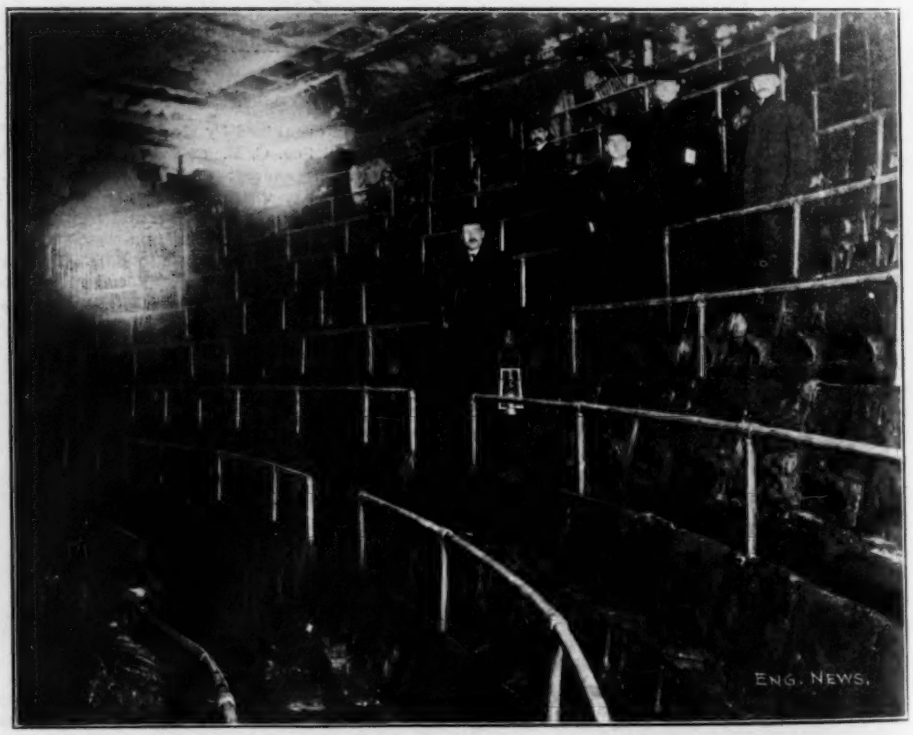
(There was little sign of fire in the orchestra back of these first rows of seats. The hangings in the box at X were not burned.)

THE CHICAGO THEATER FIRE.

As a supplement to our article of last week on the burning of the Iroquois Theater at Chicago, we present herewith some photographs of the interior after the fire. We call attention here, also, to a typographical error in that article. On p. 22 (3d col., 35th line), it is stated that in the parquet the upholstering of "the first row of seats" was burned. This should read, "first eight rows of seats."

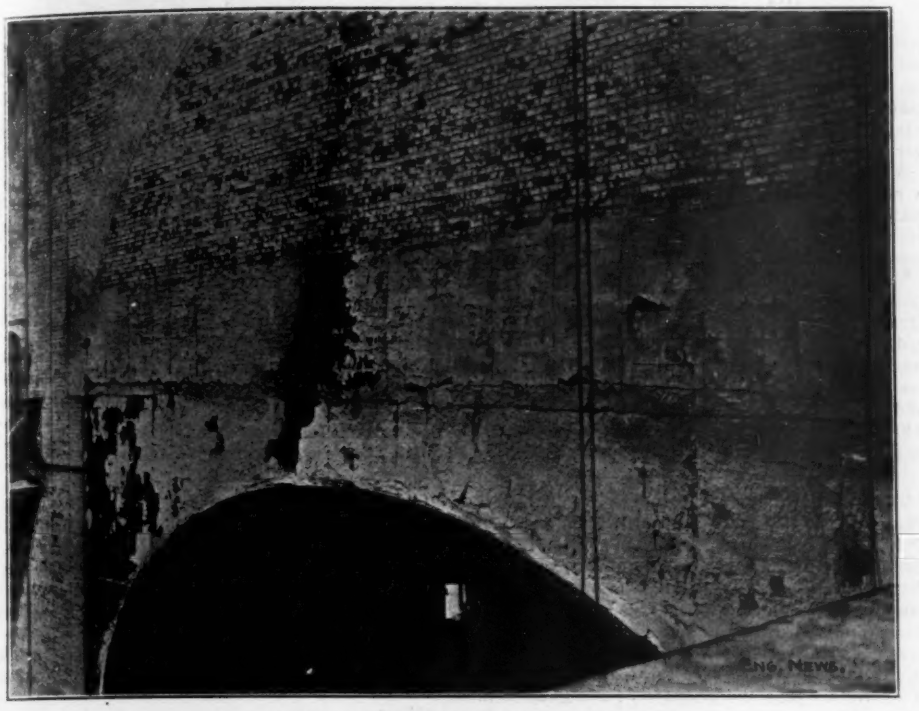
It has already been explained that one reason for the extent of the disaster was the fact that there was no opening over the stage for the escape of the fire and hot air, which was thus forced through the proscenium arch when the admission of fresh air from the rear door of the stage caused a fierce draft. It now appears that the ventilator and two skylights over the stage, as previously described, were all closed. The skylights, which were designed to open automatically when released by the melting of a fuse wire, or by the operation of a lever (never put in place), were held shut by timbers put against them for that very purpose, and a foreman of the Fuller Construction Co. has admitted under oath that on the day after the fire he took men to the roof of the building and knocked these timbers away. He was seen at the time by the occupants of a neighboring office building, which led to an investigation resulting in his arrest. This timbering was put up by employees of a sub-contractor (who have been held as witnesses), but by whose orders it was done does not appear. It is asserted that if these skylights had opened, as they should have done, the fire would have been confined to the stage portion of the building.

The seating capacity, as given by the managers, is 1,606, as follows: Lower floor, 698; dress circle, 421; balcony, 447; boxes, 40. Every seat was taken and over 220 persons were standing in the spaces between the rear seats and the walls; in



VIEW IN THE BALCONY OR UPPER GALLERY.

the upper balcony, which was very steep, people were even sitting on the steps of the aisles. These extra people included those with passes and standing-room tickets.



THE PROSCENIUM ARCH FROM THE STAGE.

(The position of the box girder over the arch and of the relieving arch above is evident. The dark patch above the arch is where the plaster was knocked off the wire lathing; but the 6 ins. of concrete protecting the girder is intact. The dark patch at the haunch of the arch is plaster knocked off the decorative portion of the arch.)

The number of dead, which was reported to have reached 591, is now said to be 566, as the shifting of bodies from one morgue to another led to their being counted twice. It is said that no less than thirty bodies were found in the trap formed by the locked door to the manager's office at the front end of the gallery opening directly from the upper door of the balcony. The arrangement of stairways was defective in that persons coming down the stairs from the upper door of the balcony had to pass the lower door in order to reach the next flight of stairs, and through this door the fire was pouring and people were rushing. Had the upper gallery above mentioned extended to a separate stairway to the street (as might naturally be inferred by people coming out of the theater), instead of to a private office with locked door, many lives would in all probability have been saved.

Another important feature is that the inner (wooden and glass) doors to the fire escapes opened inward, and as the handle had to be raised (not turned) to draw out the top and bottom bolts, it would be practically impossible to open the doors with people crowding against them in an endeavor to get out, especially as the auditorium lights had been turned out during the performance and were not lighted after the alarm had been given. These doors had no locks, but the evidence of people who were in the theater shows that they were very inefficient as emergency exits.

As to the condition of affairs on the stage, more evidence is coming to light from the examination of the employees. One man has testified that a swinging bracket carrying electric lights was in such a position as to effectively prevent the fall of the curtain, and it seems to have been the custom to leave the bracket in that position. It is also reported by the employees that a fire was started in a similar way about two weeks before the final accident, but was easily put out. It caused an alarm, however, and the asbestos curtain was dropped, but caught on the same bracket, which held it up 15 or 20 feet above the stage. The bracket was meant to be swung back into a recess in the wall when not in use, but the evidence given appears to show that the spectacular lighting arrangements were handled in a very reckless manner. In fact, the entire management seems to have been conducted with extreme carelessness. It has been asserted and denied that calcium lights were used. Our representative, however, saw gas tanks standing in the foyer, and it is reasonable to suppose that these were for the special lights used on the stage.

A few days after the fire, the Mayor ordered the closing of every theater in the city, until they complied with the ordinances; dime museums and dancing and meeting halls were also closed by his order. The theater managers endeavored to get permission to open by agreeing to use only the lower floor, on the plea that their employees were in need. The reply to this was that the employees must suffer for the previous neglect of their employers, and that no relaxation of the order would be made. The Auditorium Theater, however, was allowed to give concerts provided all scenery was removed. In the meantime, a special Council committee, assisted by engineers, architects, contractors and fire insurance experts, is studying the various ordinances with a view to improving and harmonizing them. Until this work is completed, the new ordinances are passed by the council, and the theaters altered and equipped to meet their requirements, the theaters must remain closed. It is expected that many of the old theaters will be abandoned, as they would require almost entire reconstruction to make them safe, and the expense of this would be prohibitive. Attention is also being given by the city authorities to the large department stores, churches, hospitals and other public institutions.

VIEW OF SOUTH END OF STAGE, SHOWING DRESSING ROOMS.

(The stage door is at the right. The concrete floors, wire lath and plaster protection of beams and wire cloth and plaster partitions are little injured.)

The detailed evidence now being given before the coroner's jury corroborates the statements made in our former article and gives special prominence to the following points: 1, The generally undisciplined and disorganized condition of the force of employees on the stage and in the house; 2, the closed skylights; 3, the entire absence of fire protection appliances (except a few hand grenades); 4, the difficulty of finding and opening many of the exits; and 5, the fact that several doors were locked. Indeed, two of the three wide double doors opening from the foyer to the street were locked, according to several witnesses.

It will be some time before the responsibility will be legally determined, but it is to be hoped that the present general agitation in cities and towns throughout the country for the safeguarding of theaters, hotels, stores, churches, hospitals, schools, etc., will not be allowed to stop until at least the worst conditions have been remedied. It is to be hoped, also, that managers and proprietors of such places will more generally realize that the mere fact of a building being of fireproof construction does not ensure safety when it is filled with inflammable material and provided with insufficient aisles and exits. Furthermore, it is to be hoped that there will in future be less of the too common practice of ignoring and disobeying city ordinances for public safety, on the part of the public and of city officials appointed to enforce these ordinances.

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Every one interested in the use of concrete and steel in combination (and what engineer is not, nowadays?) will read with interest Prof. Norton's report on another page of this issue respecting the tests recently completed by the Insurance Engineering Experiment station on the protection of steel from corrosion by embedding it in concrete. We presume most engineers are pretty well satisfied that in a dry situation concrete will protect steel from rust; but very many are doubtful whether it is an efficient protection where the concrete-steel structure is exposed to moisture or is perhaps actually under water.

In the tests described by Prof. Norton, however, pieces of steel already more or less rusted were embedded in concrete and exposed from one to three months to alternate applications of steam, hot water, dry air, moist air, and carbon dioxide. Other pieces were placed in sewers and in tide-water and even exposed to furnace gases. After this severe treatment, the specimens were cleaned of concrete and examined, and to quote Prof. Norton: "Not one specimen had shown any sensible change in weight or dimension except where the concrete had been poorly applied."

Cinder concrete, says Prof. Norton, has frequently rusted steel with which it was in contact, not, as is frequently claimed because of sulphur in the cinder, but because it was mixed too dry and hence in placing, portions of the steel surface were not in actual contact with the concrete. To avoid this condition in concrete, it must be mixed wet and mixed thoroughly. Concrete mixed dry, according to the standards which were generally considered good practice a dozen years ago, cannot be so closely packed as to avoid the possibility of voids, even by the most diligent ramming, and this is particularly true where the concrete must be packed around narrow sections of steel.

In this connection, the collection of letters in this issue on the mixing of concrete, particularly with reference to work done by hand, is of special interest. On most of the work where concrete is used to protect steel in building construction, hand mixing will naturally be used, and since thorough mixing is important, not only to secure good quality in the concrete, but also effective protection of the steel from corrosion, methods of mixing, to the smallest detail, are worth the careful attention of engineers.

A very great number of people are now using concrete and concrete and steel in combination in a great variety of structures. Among these users are not a few whose competence to design or to construct is at least open to doubt. It is not at all surprising, therefore, that failures of these structures, such, for example, as the one illustrated in our last issue, should occur from time to time. Such failures are probably a necessity to teach the reckless and the ignorant that recklessness and ignorance will carry the same penalty here as in other types of construction.

A chain is no stronger than its weakest link, and a concrete or concrete-steel beam or column or slab is no stronger than the section through the spot where the poorest-mixed batch of concrete was incorporated.

Engineers have been accustomed for a generation to use concrete for foundations and substructures, where an occasional batch not up to standard would make no very serious difference. It must be realized that in many of the places where concrete is now put conditions are entirely altered; and not merely good average mixing but mixing which shall permit no poor concrete to enter the work is absolutely necessary to safety.

The disastrous head collision on Dec. 26 on the Pere Marquette R. R., in Michigan, was due to the extinguishing of the lamp in a train order signal at a station. Under the block system, the extinguishing or failure of a lamp should not cause danger, for the block system gives a positive safety indication, and the absence of a signal is always to be construed as "danger." It is one of the inherent defects of the train-order system of operation that the absence of a signal means safety. Hence, if a signal lamp is extinguished or a day signal is blown down, or if from mere neglect the danger signal is not set, the train goes ahead. It is manifest that to make the safety of a train load of passengers depend on the burning of a feeble flame in a lamp exposed to storm and tempest on a signal pole, is little short of criminal neglect. The only possible defence for it is the fact that for many years railways have been run on this system—or lack of system—and have not killed enough people to compel a change to something safer.

Of course, to have the block system effective, it must be obeyed. Engineers and firemen must be absolutely governed by it, and the rule that the absence of a signal is always a danger signal is a necessary part of the system. If this rule be broken, just such a wreck as that on the Pere Marquette may be caused.

An interesting newspaper story comes from Chicago concerning a test said to have been made on January 7 by officials of the Chicago & Northwestern Ry. to determine whether the train crews running under the block system were obeying this rule to stop at a semaphore whose light was out. We quote as follows:

> At Mayfair, a station just inside the western city limits and on the main line of the Northwestern, the officials took possession of the station and to the astonishment of the agent put out all the semaphore lights. When a semaphore light is out it is the same as a red danger signal, and all trains should stop for orders.
>
> To the chagrin of the officials, one passenger train after another passed by without the slightest slowing up until no less than eight trains had whizzed along. This included the fine Northwestern Limited for the coast. After the trains had passed the lights were again lit and the officials went back to headquarters and laid off all of the eight train crews for ninety days.
>
> To-morrow general warnings and new orders will go out, and hereafter those violating this rule or any others of like importance will be dismissed forever from the service of the road.

We do not vouchsafe for the accuracy of this story; in fact, it seems well-nigh incredible that such habitual neglect of signal observance as the above would indicate can exist on any well managed railway. So far as it may be true, however, and so far as engineers are found to disobey the indications of block signals, it is not to be taken as an argument against the block system; but an argument for better training and discipline of employees, and for extension of the block system, so that all employees shall become more accustomed to its use and shall form the habit of implicitly obeying its indications.

As we have many times pointed out, American engine runners and firemen, almost without exception, have gained their experience under the train order system of operation, and have become callous to the risks which it involves. It will take years of experience and training to eradicate the bad habits which have been formed and to create such faithful and conscientious regard for signals as exists on English railways, where employees have never known anything but the block system in all their experience.

Attention is called to the percentage of macadam shrinkage under rolling, as given by Mr. J. Albert Holmes elsewhere in this issue. Strips of canvas (12 × 12 ins.) were placed upon the gravel subgrade, and, after rolling, measurements were made from the macadam surface to the canvas. These measurements showed a shrinkage of only 15% under steam rollers weighing from 12 to 15 tons, whereas a 33% allowance for shrinkage is often made by engineers. In Gillette's "Economics of Road Construction" careful measurement of the loose stone in wagons at the bins and subsequent measurements by plugging the compacted macadam showed a shrinkage of 20% for limestone. It is exceedingly difficult to determine with accuracy the exact shrinkage under rolling, due not only to the difficulty of making accurate measurements on thin macadam in place, but to the fact that on a soft subgrade some penetration of the stone into the subgrade occurs. On a hard gravel subgrade where the division plane between the subgrade and the macadam is easily marked either by strips of canvas or by the distinctive color of the gravel surface, it is possible to measure the shrinkage with considerable accuracy. The statements that are still to be found in some modern text-books to the effect that 50% shrinkage occurs are certainly erroneous, and it is probable that no hard stone shrinks more than about 25% under rolling, if as much as that.

Mr. Gillette has attributed the rule allowing 50% for shrinkage to a copying of an English rule formulated in the days of Macadam when steam rollers were not used. Then the traffic of months brought the road down from 12 ins. to 8 ins. in thickness, but, in doing so, much of the stone was pulverized. With modern methods of road construction, there is very little dust made by the steam roller, the dust that effects the final binding being supplied in the form of screenings from the rock crusher. Hard rocks, like trap, often supply an insufficient amount of fine dust in the screenings, hence the difficulty of binding under a steam roller unless a small quantity of limestone dust or earthy material be added during the final rolling.

Many of our readers familiar with the history of air-brake development will recall that at the first series of Burlington brake tests in 1886, the shocks with the 50-car air-braked trains were so serious that it was generally agreed among the experts that electricity would have to be adopted to operate the triple-valves in order to secure instantaneous application of the brakes throughout the train. Such a system was worked out by several brake companies; and at the Burlington brake tests of 1887 both the Westinghouse and the Eames trains were equipped with electrical apparatus to secure quick application of the brakes. Shortly afterward, however, the quick-action triple-valve of the Westinghouse Company was perfected to such a point that the use of electricity in connection with air brakes was abandoned, and no American inventor has since then thought it worth while to do any work in this field.

On the other side of the water, however, complication has no terrors for the engineer or the railway manager; and hence it transpires that this scheme which was worked out and abandoned in this country 17 years ago has recently been taken up by the Siemens & Halske Co., of Berlin, and has actually been applied on a German railway. A foreign contributor, whose English is more literal than idiomatic, sends us an account of this "new" invention, which he terms a "pneumatic brake with electric command," and we quote verbatim from his opening sentences as follows:

> The Company Siemens and Halske was induced to study this system because, in their opinion, the Westinghouse brake would have serious defects. It reproaches the latter, particularly, with the slowness of working, which ex-

poses the last wagons to strike violently against those which are already braked; with the great difficulty of braking trains with several conductor wagons; with the not-working in the case where, in consequence of the slow decrease of pressure in the pipes, the valve would not be reversed; with the impossibility of braking the wagons placed behind the coupling-cock in the case where it would have been forgotten to open the same.

The electro-pneumatic device Siemens and Halske aims at avoiding these drawbacks. It allows to actuate simultaneously, from any point of the train, the brakes of all the cars, whilst permitting the automatic braking's taking place when the pressure of the general conduit falls below the fixed limit.

It does not change anything at the pre-existing dispositions and allows to perform the manipulations as before, when the electric command is done away with.

Between the principal conduit and the brake-cylinders are interposed valves, kept closed by the pressure of the air but which can be opened under the action of electro-magnets and causing the braking to take place. The electric current is thrown into these electros by the working of a commutator thrown into gear with the brake-cock of the machinist.

We do not think it necessary to follow farther the detailed description of the apparatus given by our contributor. We will merely note that it has been tried on the military railway from Berlin to Zuterborg and has "perfectly worked in the daily service and has not met with any aversion of the personnel," which, if true, would indicate that the personnel were of different makeup from typical American train crews.

The objections to the combination of electric and pneumatic operations in continuous train brakes are so many and so obvious that it is a matter for surprise to find so prominent a German firm as Siemens & Halske expending money on such a system.

The fact is that European railways are half a generation behind American lines in railway brake development. If they desire to improve their practice they can make much better progress by studying what has been done on this side of the water than by trying to develop more complicated apparatus in a field where correct working is absolutely essential to safety.

THE ORGANIZATION OF SECTIONS IN ENGINEERING SOCIETIES.

Some notable changes are in progress among American engineering societies. One which has attracted much attention and which we commented on some time ago, is the formation in national societies of local chapters or sections. The largest and most successful venture in this field has been made by the American Institute of Electrical Engineers, but the Institute of Architects and the American Chemical Society are each made up of local chapters, and there has been a movement to have the local section plan adopted in the American Society of Mechanical Engineers.

What seems to us an even more important departure is the organization of sections devoted to special branches of engineering. Certain societies, indeed, have been operated on this plan for many years. The Franklin Institute, for example, has had for a very long time a considerable number of sections which meet almost as if they were independent organizations. Another prosperous Pennsylvania organization, the Engineers' Society of Western Pennsylvania, has had for years a section devoted to chemistry. As the section is chiefly made up of chemists connected with the local iron and steel works, naturally this branch of chemical work is the one to which most attention is devoted.

The Canadian Society of Civil Engineers, as many of our readers will remember, occupies the unique position of holding a legalized monopoly of engineering practice in portions of Canada, and seeks to obtain similar powers throughout the Dominion. The Quebec Act provides that no person not a member of the Society (with certain exceptions) shall practice as a civil engineer, and it defines the term "civil engineer" as follows:

(d). The expression: "civil engineer," means any one who acts or practices as an engineer in advising on, in making measurements for, or in laying out, designing or supervising the construction of railways, metallic bridges, wooden bridges, the cost of which exceeds $600, public highways requiring engineering knowledge and experience, roads, canals, harbours, river improvements, lighthouses, and hydraulic, municipal, electrical, mechanical, or other engineering works, not including government colonization roads or ordinary roads in rural municipalities; but it is not deemed to apply to a mere skilled artisan or workman.

It will be seen from the above that the Society can lay claim to a monopoly of electrical and mechanical engineering work as well as of the classes of work more commonly classed as civil engineering. Naturally the law also contains provisions requiring the Society to admit electrical and mechanical engineers to membership, and, in fact, practitioners in any branch of engineering who can show their competency before an examining board. There is, of course, no voting upon applications for membership, either by the Society's members as a whole or by its governing body. Any engineer of sufficient competence has a legal right to membership, which may not be denied him.

Our readers who wish to study further the unique departure which the Canadian Society has made are advised to obtain from the Secretary at Montreal a copy of the Society's constitution now in force, together with the legislation which has been enacted. We have called attention to it at this time, however, merely to note that an outgrowth of this departure has been the establishment by the Society of special sections devoted to electrical and mechanical engineering.

Another society which has recently taken the step of establishing branch sections is the Boston Society of Civil Engineers, which is, by the way, among the very oldest engineering societies in this country.

In doing this it has gone farther than most Societies in the way of giving the sections a semi-independence. For example, a person may be a member of a section and not a member of the general Society at all. This gives the sections a large possibility of development. Let it be supposed that it is desired to organize a section to be devoted to mechanical engineering. It should be possible to obtain a large membership for such a section in and about Boston among persons who have not been members of the Boston Society of Civil Engineers at all, and who would not, naturally, enter that organization, and yet who would be able to make valuable contributions to such a section.

Of course the possibility has to be faced that any of these semi-independent sections may forge ahead with such vigor as to outgrow the parent society and eventually to become independent of it. It is of interest to see how this has been guarded against, so far as possible, in the new constitution of the Boston Society of Civil Engineers. Inasmuch as this same problem is likely to come up in other societies which may undertake to establish special sections, we have thought it worth while to reprint the portion of the Boston Society's new constitution referring to this as follows:

15. Sections.—The Board of Government may from time to time, at its discretion, establish sections for the consideration of special branches of engineering. Such sections shall in all cases be known as "The [name] Section of the Boston Society of Civil Engineers."

Each section shall consist of not less than ten members of the Society, with such other persons as shall be elected by the section as its members after approval of their applications by the Board of Government.

A member of a section who is not otherwise a member of the Society, shall be entitled to attend all meetings and excursions, to use the library, and to receive the publications of the Society, to take part in the discussions of any papers on professional subjects, or of any business affecting his particular section at any such meeting, but shall have no vote, except in his section.

Papers read before sections and discussions thereon may be reported in accordance with the section by-laws, and shall be published in the same manner and subject to the same conditions as obtain with respect to papers read before the Society.

All sections shall be governed by the Constitution and By-Laws of the Society, so far as applicable, but they shall be entitled to make additional by-laws for their own use and government; provided, however, that said additional by-laws be not inconsistent with the Constitution and By-Laws of the Society, and that they be approved by the Board of Government.

The officers of each section shall be a Chairman, Vice-Chairman, and Clerk, who shall be elected by the members of the section annually.

The general government of each section shall be vested in an Executive Committee, consisting of the President of the Society, the officers of the section, and three additional members of the society who shall be elected annually.

The fees and dues for members of sections who are not members of the Society shall be:

Entrance fee	$5.00
Annual dues	5.00

which shall be paid to the Secretary of the Society. The dues for the remainder of the first fiscal year after date of election shall be remitted to members of sections.

Members or associates of the Society may, without election, become members or associates of any section, under such regulations as may be prescribed by the by-laws of the sections, without the payment of additional fees or dues.

Any member of a section upon becoming a member of the Society shall pay the difference between the entrance fees of the Society and the section, but shall pay no dues to the Society for the remainder of the fiscal year after his election.

The Chairmen of sections shall be entitled to be present at the meetings of the Board of Government, but without votes.

Any section may be abolished by the Society by a two-thirds vote of all the members present at any regular meeting, upon recommendation of the Board of Government, due notice of such recommendation having been sent with the notice of the meeting to each member of the Society, and to each member of the section in question who is not a member of the Society; and all members of the section in question shall be entitled to be heard at this meeting.

Resignations, forfeiture of membership, or expulsion of members of sections shall be governed by the same conditions and methods of procedure as apply to members of the Society.

It will be seen that the parent society's "Board of Government" passes upon all applications for membership in any section and upon the special by-laws which any section may make. At the same time each section is left to choose its own officers and to a large extent to develop along such lines as are found most advantageous.

Another notable illustration of the division of a Society into sections was furnished at the annual meeting of the American Society of Testing Materials last July. This young Society is, of course, devoted to one narrow specialty in engineering—or at least it might be considered a narrow specialty; and yet it was found advantageous at that convention for the Society to meet for part of the time in two sections, one for the consideration of papers on the testing of cast iron, the other to take up papers on cements and asphalt.

We believe the organization of sections in Engineering Societies to be to a high degree advantageous and, in fact, a necessary result of the specialization which has taken place in the engineering profession itself. The engineer who goes to the trouble to prepare a professional paper for presentation before a Society, desires above all things to have it heard or read by men competent to understand and appreciate the ideas which he puts forth.

We have frequently heard papers presented before engineering societies of national reputation, which represented weeks of toil and research on the part of the author; and yet the paper was received by the audience without the slightest token of interest and without a word of comment or discussion being offered.

In contrast with this we have heard sharp and intelligent discussions in small organizations devoted to a special branch of work. Here the reader of a paper knew that the audience before him could understand every statement he made, and that there was no use in presenting platitudes or vague generalities. It is the papers read and the discussions engendered under such circumstances that make most largely for professional progress.

LETTERS TO THE EDITOR.

The Use of Wooden Studs to Locate Sewer Y's.

Sir: The recommendation by Mr. E. T. Abbott in your Construction News Supplement of Dec. 31 for the use of a wooden scantling or stud at the end of each sewer branch to mark its location is an excellent one for other reasons than those given by Mr. Abbott. If the engineer wishes to locate the branches as placed rather than to leave the measuring in of them to inspectors he has a better opportunity for so doing without holding in check the backfilling. Also, the finding of the stud by the plumber enables him to start his house drain trench with good assurance that when he has dug down to the Y he will have room in which to make the proper entry of the Y without reversed curves in the house drain. We have used such studs in all our sewer work of the past nine years, with one exception caused by the economy of the sewer board. This economy (?) is being met in various ways by the expense to property owners caused by erroneous measurements by the inspectors or by the plumbers. As the cost of these studs seldom exceeds an average of $25 per mile of sewer, except in front of business blocks and very closely built up city residence streets, it takes very few erroneous locations, especially when occurring where the sewers are laid in deep trenches, to result in greater expenditure than the use of the studs.

Knight & Hopkins.

Rome, N. Y., Jan. 5, 1904.

Zero Azimuth.

Sir: Replying to the question of "Engineer" in your issue of the 7th inst., Professor Johnson used the South point as zero azimuth because that is the zero point

of astronomers, and consequently the convenient point for geodesists, much of whose work is astronomical. In the judgment of the writer this is not a sufficient reason for changing the zero point from North to South in ordinary land or topographical surveys, and "Engineer" will find the matter discussed at page 162 of Raymond's "Plane Surveying," which advocates the North for the zero point of azimuth. Beside the universal custom in this hemisphere of referring to the North as a base for descriptions and orienting and land survey computations, the North point has this further advantage in tabling surveys recorded by distance and azimuth: The azimuth need not be reduced to bearing, since the size of the azimuth angle gives from the ordinary trigonometric notion the correct sign for the latitude and longitude differences; thus, in the first quadrant both signs are plus and both sine and cosine are plus; in the second quadrant latitude is negative and cosine is negative, while longitude is positive and sine is positive; in the third quadrant all signs are negative; in the fourth quadrant latitude is positive and cosine is positive, while longitude is negative and sine is negative.

0°	to 90°	Cosine	+	Lat.	+.	Sine	+ Lon. +.
90°	to 180°	Cosine	—	Lat.	—.	Sine	+ Lon. +.
180°	to 270°	Cosine	—	Lat.	—.	Sine	— Lon. —.
270°	to 360°	Cosine	+	Lat.	+.	Sine	— Lon. —.

Wm. G. Raymond.

Rensselaer Polytechnic Institute, Troy, N. Y.,
Jan, 8, 1904.

Licensing Engineers and Architects.

Sir: As an admirer and close reader of Engineering News, I beg to inquire its opinion in reference to the subject mentioned in the enclosed letter, published in the New York "Sun," Jan. 4. Has the question lately been discussed in Engineering News? What is the general opinion of the majority of *reputable* engineers and architects regarding it? Very truly yours,

Edw. W. De Knight.

120 Liberty St., New York City, Jan. 5, 1904.

The letter published in the "Sun" is as follows:

SHOULD ARCHITECTS AND ENGINEERS BE LICENSED AND HELD RESPONSIBLE?

To the Editor of the "Sun"—Sir: In the frightful Iroquois Theater calamity, has any one inquired into the liability of the architect and engineer who drew the original specifications of the building? Was the architect criminally careless in any detail? Is it not high time that, like physicians, architects and engineers be under state examination and regulation? Does not the Chicago catastrophe point that way? Where the mistake of a physician may destroy one life, the error of an architect or engineer in the designing and building of a bridge, tunnel, office structure, school, theater, factory or home may destroy hundreds of lives.

Edward W. De Knight.

New York, Jan. 3.

(Answering now our correspondent's queries, Engineering News has taken no editorial position with reference to the proposals to license engineers and architects, or to make them "close professions," so-called, except to point out that the burden of proof is upon the advocates of the licensing system to show that it could be made practicable and that the benefits would be greater than the disadvantages. Incidentally it is of interest to place on record the fact that the state of Illinois has had in operation for several years a license law for architects; and all architects doing business in that State have to pass an examination before a State Board of Architects and receive a license. Incidentally also we may remark that nothing in the evidence thus far obtained regarding the Iroquois theater disaster shows culpability on the part of architects or engineers.—Ed.)

Safety in Third-Rail Electric Traction.

Sir: I have read with great interest an editorial appearing in your issue of Dec. 24, 1903, upon the subject of electric power as used in the operation of heavy traction lines.

There is no controverting your statements as regards the present methods employed. There is not the slightest ground for argument as regards the systems in use, nor the added danger to human life; neither can it be disputed that the third-rail method is the latest means of conducting adequate power to moving trains; but it does not necessarily prove that there is no system of protection to be afforded to such heavy electric power conductors.

As to this feature I beg to take issue with you, as also to several other features touched upon by you, and which I will endeavor to treat seriatim:

Mr. George Westinghouse, in his open letter to the New York "Times," under date of Aug. 29, 1903 (which was brought out by the Paris tunnel accident, to which you also allude), gave, to my mind, a clear statement of conditions and future requirements; but only in the abstract, not pertinent as to details. The conditions mentioned, however, when viewed from a practical railroad operating standpoint, must sooner or later be met by all heavy traction lines using electricity as a motive power.

Operating the power feeder in set, given sections, whereby only that section upon which the car or train may be operating will be energized, will undoubtedly be the future method, in order to provide not only adequate power for any motor or series of motors, but also absolute protection against all accidents as well as outside interferences, and while it is true that to cut the power off from any operating feeder section when occupied by an operating train at which time there is an outlet for the current through the motors, would be a very difficult and dangerous task, and similar to the closing of a large water main gate compared to that of an ordinary faucet, it should be borne in mind that this comparison applies only under pressure and current.

These conditions, however, would be vastly different were the outlet for current at the necessary high pressure removed. A water-wheel will render full pressure power if you have "water head" (equivalent E. M. F. pressure) and current capacity (equivalent C. amperes current electrically) with a clear "tail race" (equivalent good return circuit or ground), but if you "back water" upon the water-wheel, or cut off return circuit for power, it is safe to say that the pressure will be so reduced, in either illustration, as to make the operation a very simple and yet effective task. Therein lies the secret of successful operation of a high electric power feeder sectional system. To operate such a sectional system, meeting *all* requirements as regards protection and also demands for power, the current must be cut upon the section *before* the car reaches such section, ready to supply the motors the instant the car enters that section, and the power upon the last preceding section MUST NOT be taken off while the car is depending upon that section of feeder bar for its power. Operating in this manner, the current is not taken off any section of the feeder until the *outlet* has first been removed by virtue of the car or its collectors having made contact with another source for its supply, or in other words, the motors have ceased to receive power from one section by passing into the next succeeding section, upon which it has previously cut the power or current and by the use of the latter power is enabled to cut it off from the last preceding section without the slightest difficulty, or arcing or sparking. Under this same operating principle may be classed the application and operation of proper and adequate safety devices, and which may, by virtue of the sectional operation, be truly termed never-failing. All this is accomplished beyond doubt because of the fact that when the sectional power feeder—or, as more commonly called, the third-rail—is operated in sections, it provides a means of electric home and distant signals and safeties by direct connection therewith, which are operative only so long as that particular section may be operative or energized.

Operating sectionally upon this basis, it will be apparent to any expert or experienced operating official that if a given car is being furnished power for its motors from a given section, it can also provide power for the operation of any desirable auxiliary, and while taking power through one set of collectors, is capable of giving power through the other collectors not then in contact with the power feeder. Thus, if a section of feeder one mile in length be charged and occupied by a car, that car may utilize the power to operate a power control, cutting the current off the section last occupied, de-energizing same while not being used, and at the proper time before entering the next section, operate the control to throw power thereon ready for use when the car enters that section, repeating the operation, section after section. It is also obvious that under such a system of power control, sectionally, any train may be protected against rear or head-end collisions while within such section, by carrying a conductor wire from each end thereof, any desired distance beyond, and attaching it to a proper contacting safety that, when contacted by another car without running rights, will close a circuit through the cab of the latter car, by which means the power will be cut off within the cab and air valve opened, thereby setting the brakes and bringing the car to a stop; and whenever this condition obtains, the car moving in the opposite direction would also be stopped in the same manner by means of the electric safeties of the sectional feeder of the trespassing car.

Great stress is being placed upon the necessity for a means of shutting off the power in case of an accidental shorting of the power circuit through a derailment or otherwise. This should and would also be accomplished by the power controls placed in each section, whereby a sudden short overload closes a local circuit within the "control," operating mechanically and electrically, cutting power from the section, which remains cut off so long as the short remains, thereby preventing any other train or car from entering that section or obtaining power therefrom.

The dangers of what we may term the "open or unprotected third-rail," as used upon elevated roads and some few surface lines operated by electricity, may well call forth public condemnation, and so long as the managers continue to justify the use thereof by the statement that it is the only system of distributing adequate power to handle their trains, so long will they subject themselves to severe public criticism. As it is simply a question of capacity of feeder, it matters not as regards being protected or unprotected. As much can be carried in a quart measure of wood as one made of tin, therefore the fact of protecting a 70-lb. American Society of Civil Engineer's section of steel rail does not detract from its carrying capacity; on the contrary, it increases it by preventing losses and at the same time removes the annoyances of weather interferences and the danger to human life from accidentally coming into contact therewith.

Another feature of great moment in connection with the operation of elevated roads by a protected system fully worked out and demonstrated versus the open third-rail with its gravity, floating collector shoe, is the elimination of noise. The gravity shoe of magnetic metal, operating within its natural tendency to escape from the center of gravity, when traveling against the resistance of the atmosphere, is a constant menace to the direct application of power to the motors, first, by the interposed resistance between the full capacity third-rail and car controller, and second, by its gradually decreasing contact as speed of train increases, and third, by the great loss of power pressure when it reaches the point of arc. On the contrary, a protected system without accumulation of carbon or dirt upon the contact face of feeder, a collector of high conductivity held in contact by regular and reliable even pressure without any tendency to vary its position, interposes no resistance in the circuit and is not influenced magnetically, delivers the highest efficiency to the motors, and above all, is without objection as regards noise or "grinding effect" upon the feeder bar or rail.

Are not these features worthy of consideration by those who desire to occupy a section in the first van?

Very many more pertinent points might be treated upon in favor of the protected sectional system, all of which are, like these covered, susceptible of proof, all having been fully demonstrated up to 3,000 HP., electrically speaking. Yours truly,

E. W. Farnham,
President The Farnham Company.

108 La Salle St., Chicago, Ill., Jan. 4, 1904.

Custom as to Payment for Clearing and Grubbing.

Sir: In answer to the recent query about clearing and grubbing by the acre:

In the first place, the clearing and grubbing should not be combined. The area cleared is seldom the same as that grubbed. The specifications generally confine the grubbing to excavations and under embankments of less than 2 ft. depth. Grubbing for borrow pits on right of way is at the contractor's expense. It is one of those things that is put in to get something for nothing, viz., the railway company expects the price of clearing to be no higher if the grubbing is included.

It has been a custom to estimate full clearing when the branches of trees touch; and if there are isolated trees the area covered by vertical lines from tips of branches is generally a fair measure of ground cleared, and with the "combined" specification it also pays for the grubbing. With the small tree, the area covered being less, it equalizes the smaller expense of removing the stump.

A. C. E.

Brandon, La., Jan. 7, 1904.

What Constitutes an Acre of Actual Area Cleared.

Sir: In answer to your request for an expression of opinion on Mr. Dodd's inquiry regarding "what constitutes an acre of the actual area cleared," I would hazard the following:

Under the specification that "grubbing and clearing shall be paid for by the acre of the actual area cleared," any timber growing in such contiguity as in a grove, orchard or woods, irrespective of how close the timber was standing, if only the line and limits of the growth were well defined, should be classed as clearing.

Second, the area allowed for an isolated tree should depend on the size of the tree and what in the Engineer's opinion would be a fair price for its removal. I find a difficulty in quoting any rule on such a matter, but in my personal experience I have never found it a hard thing to arrange such affairs with a contractor on a basis of fairness. Having been fortunate enough to have always been employed by companies who were willing that the contractor should have everything he was entitled to, I have been able to justify such allowances as I have made on taking into consideration the work performed. If clearing is entirely through dense woods there is, of course, no question of area, but I infer that your correspondent's case is in an agricultural country containing patches of woodland. Therefore, the clearing in such a country must be a very insignificant item, and in such cases I think that the engineer or contractor who gets down to fine work makes a mistake. The insistence of a contractor that he should be allowed clearing for a tree which probably occupied a laborer half an hour in its removal, would utterly disgust any engineer who was trying to be fair, and, on the other hand, the refusal of an engineer to pay more than a nominal sum for some large, old oak or elm whose removal undoubtedly cost a comparatively substantial sum, would discourage a contractor who was honestly trying to do his duty. No specification that ever was written covers every point, and as a rule contractors appreciate the efforts of engineers, even in small matters, to arrange extraordinary items on a basis fair to both parties.

That there are exceptions, who, having obtained an

inch diligently endeavor after an ell, I readily admit, but even that does not absolve the engineer from giving the greedy and appreciative an absolteuly fair and common sense award. An engineer cannot afford to sacrifice his self-respect by allowing his personal feeling to influence him in any way, and therefore, in the comparatively insignificant matter of clearing I should take the circumstances into consideration and give such an area in isolated trees as the facts warranted. For instance, if an isolated tree, in my opinion, cost $10 to remove, and the price for clearing was $100 per acre, I should allow one-tenth of an acre; if another isolated tree cost 15 cts. to remove I should take no notice of it. If in continuous woods the contractor lost or made money on the clearing I should feel that he was working under the specification pure and simple, and that I had no option but to give him the area within the defined lines.

Yours very truly,

Thos. H. Mather.

Syracuse, N. Y., Jan. 2, 1904.

An Interesting Legal Decision Relating to Clearing and Grubbing.

Sir: In response to inquiry of Mr. J. T. Dodd relative to what constitutes actual clearing, I would cite him to a case that came under my observation during the construction of the Montgomery Division of the M. & O. R. R. in 1897. The right of way for that part of the railroad between Tuscaloosa, Ala., and Montgomery, Ala., was cleared during 1890 and 1891. The grading was approximately 75% completed during these years. Then work was suspended until 1897. The Hanover Construction Co., of New Jersey, took the contract to complete this road, "ready for traffic," for a stipulated sum of money. The Hanover Construction Co. let 20 miles of new work west of Tuscaloosa and 100 miles of the old work (or work that had been cleared and 75% of grading done) between Tuscaloosa and Montgomery to R. M. Quigley & Co., of St. Louis, on a unit basis, the price for clearing and grubbing being $23 per acre, "where clearing is actually done." During the six years that work was suspended this old grade and right of way had grown up in briers, vines and bushes; there were also a few "isolated" trees, stumps and logs that had not been removed during the first period of construction. Quigley & Co. sub-let the clearing and this old work to Williams & Morrison and J. D. Caples et al, "subject to estimate of the engineer in charge." The writer held that, where any clearing was to be done on a station (or 100 ft.) the contractor was entitled to "full clearing," although in many instances there were only a few small trees or probably only briers, bushes and vines on the station. Some of the other engineers on this work concurred in my opinion. The position we took was that we were not called on to classify the clearing, but simply to judge whether any clearing had been done or not. Our chief engineer, Capt. H. P. Farrar, and some of the other officials of the Hanover Construction Co. differed from us. And orders were "unofficially" issued to the engineers by a member of the Hanover company to give from one-fifth to one-third clearing on this old grade. The writer refused to turn in such an estimate, but turned in an estimate he believed to be correct, and gave a copy of same to the sub-contractor. This estimate was promptly paid; however, some of the engineers either followed their "unofficial orders," or their own judgment, and gave from one-sixth to one-third clearing on the old work. The result was that Williams and Morrison brought suit against R. M. Quigley & Co. Other suits were filed at the same time by J. D. Caples, H. J. Ward, M. M. Williams et al, all the plaintiffs asking the court to have Quigley & Co. pay them full clearing for each and every station (or 100 ft.) cleared. This was a friendly suit between R. M. Quigley & Co. and their sub-contractors, an agreement having been made between Quigley & Co. and the Hanover Construction Co. whereby the Hanover company was to pay Quigley & Co. for the same acreage that the court ordered Quigley & Co. to pay the sub-contractors.

The writer was summoned by all the plaintiffs as an "expert on clearing and grubbing." The Hanover Construction Co. had 12 or 13 engineers summoned for the defense. The case was ably handled by some of the best legal talent in Alabama on both sides. The following is an abstract of the decision of the court: "The court holds that where any clearing has to be done on any station (or 100 ft.), that it shall be estimated as clearing, and the court further holds that the size or number of trees, bushes, briers, etc., cut from any station does not have any bearing on the case, the specifications setting forth that clearing and grubbing shall be paid for when it is actually done." The court also ruled that 100 ft. should be used as a basis of measurement because it was proved by all the witnesses, both for the plaintiffs and the defense, that 100 ft. was the customary unit used in estimating clearing. The court rendered its verdict in favor of the plaintiffs and ordered estimates made accordingly.

Although this case involved more than $23,000 no appeal was taken and the award of the court was promptly paid.

Respectfully yours,

Woolsey Finnell.

Tuscaloosa, Ala., Jan. 4, 1904.

A Method of Mixing Concrete by Hand.

Sir: I note the letters in your journal concerning methods of mixing concrete by hand and send description of a method often used on sewer work in this vicinity.

A tight "mixing" box about 8 ft. long, 4 ft. wide and 10 or 12 ins. deep, and a platform 9 ft. wide, 12 ft. long, of ⅞-in. matched boards laid on 2 × 3-in. pieces, are built, and the box is placed beside the platform. The boards forming the long sides of the box and the 2 × 3-in. pieces of the platform are allowed to project 1 ft. on the ends, and are shaped to form handles by which each is easily moved.

The cement and sand, properly proportioned, are mixed dry in the box; then water is added and a fairly "wet" mortar made. Meanwhile the broken stone or gravel is placed upon the platform in a layer 6 ins. thick (being usually measured in a bottomless box), and is thoroughly wet from hose or buckets. The mortar is then cast over the stone in a fairly uniform layer by means of shovels. The mass is then turned over two or three times on the platform by means of the shovels, and thence incorporated into the work. Turning twice on the platform is usually sufficient.

This method gives a thorough mixture and utilizes the laborers to good advantage, a gang of six men being advantageously employed. Two men will prepare the mortar while four men get the stone on to the platform; all hands then finish the operation.

Yours truly,

Orlando K. Morgan.

Wakefield, Mass., Dec. 28, 1903.

Mixing Concrete by Hand and the Cost of Mixing.

Sir: I have been interested in recent discussions of practice and specifications for hand mixing of concrete. I think the best way I have ever seen it done is as follows: First, use a good smooth platform, large enough to allow freedom of motion for all; on this lay down a bottomless mortar box or frame about 4 × 8 ft. and 9 to 12 ins. deep, the size of box depending on the size of batch desired. Dump into this, and spread evenly, the sand or gravel required for a batch; on this spread the cement; mix dry with hoes; apply the water by pailfuls, say half that required for a batch at first and the rest as required in the mixing. Mix thoroughly with hoes till the mixture is of a uniform porridge-like consistency throughout. Into this thin mortar dump all the stone required for a batch, from wheelbarrows all filled ready; then lift off the frame and turn the contents with shovels. Start a pair of shovelers at one end of the pile, one on each side, and another pair a little behind them; and let them work back to the other end of the pile, thus turning the material twice. Let the wheelers follow up and load their own barrows as fast as the mixture is turned twice. If the concrete is not well mixed use more shovelers and give it another turn; but my experience is that it can be very well mixed by this method with the four turners.

Let us discuss the process by steps. Some will object to applying all the water for a batch at this early stage of the mixing, i. e., before the crushed stone is introduced into the process. When I first encountered this method of mixing mortar thin, like porridge, before applying the stone, I was skeptical of the wisdom of it. But I have many times sampled the mortar in different parts of the same boxful and, instead of finding that the water had washed the cement off the sand, to all appearances the mixture was very uniform indeed.

As to the idea that the early application of the water will give the cement a chance to set before the concrete is placed in the form, there is so little difference in this particular between the different methods of mixing concrete that I don't consider it of great importance. Good Portland cement will not ordinarily take its initial set, in a laboratory test, short of two to three hours. In case of a very quick setting cement, the excess of water used in the mortar, as above described, and the constant working of the mixture till it is loaded in the wheelbarrows, will materially retard the setting.

The dumping of the stone, one wheelbarrow load at a time, into the thin mortar accomplishes not a little mixing. Of course if the weather is very hot, or the stone very dry the stone pile should be wet down frequently.

The mortar serves to lubricate the sides of the frame so that two men have no difficulty in lifting it off and placing it ready for another batch.

Again, the thin mortar being originally under the stone serves to lubricate the platform and the stone so as to facilitate the entering of the shovel for the first turning.

I think it easier and quicker to turn the pile "endwise" than "broadside," and believe it requires less floor space for the operation.

As to the quantity of work that can be done by this method a good crew of 20 to 25 men, using two of the bottomless mortar boxes, can mix and place 45 to 60 cu. yds. of concrete per day of ten hours, depending largely on the weather, the disposition of raw materials and the length of wheel after mixing. A crew working under me last season, after one day's trial of this method, was able to put in more concrete in ten hours and do it easier than at any time by another method of mixing which it had used for two months. In fact the difference was so noticeable that some of the crew became dissatisfied with the (to them) new method, merely because they were doing more work than by the other method. The quality of concrete was first class, if anything somewhat improved by the change in manner of mixing.

As a general proposition I prefer a good machine mixer for jobs larger than 300 or 400 cu. yds., but do not consider that there is much saving in cost by use of machine unless the job is considerably larger.

H. P. Boardman,

Asst. Engr., B. & B. Dept., C. M. & St. P. Ry.

Milwaukee, Wis., Dec. 26, 1903.

Methods of Mixing Concrete by Hand and with Machines.

Sir: In your issue of Dec. 24 Mr. E. Sherman Gould gives some specifications and notes on mixing concrete. The writer has been noting the trend of the arguments on this question in several recent issues of the Engineering News, and has been surprised to find such differences in opinion.

It is human nature to believe that "He is a very smart fellow who thinks the same as I do," and this belief is very hard to overcome, but it will not do to yield to it in engineering.

If you combine part of Mr. Gould's specification with a portion of Mr. Hammon's specification you will, in the writer's opinion, get the best results.

To specify that the materials must be turned over a certain number of times is necessary in order to avoid disputes between the client or builder and the inspector. The specification should state the greatest number of turns, but the inspector should be allowed to require a less number in special cases; for when the materials are thoroughly mixed it is time to stop, and any further manipulation will rather tend to separate, and not mix the ingredients. Again, an experienced gang will make a better mixture by turning the materials over twice than a green gang will make in ten turns.

On an important job no concrete should be mixed except under the eyes of an experienced foreman or inspector. And here the "hints" given on page 365, Engineering News Supplement, Dec. 24, are especially applicable when this foreman is to be selected.

A few wheelbarrows of badly mixed concrete sent back to the mixing platform for better treatment will have a more lasting effect on the concrete gangs than a lot of talking to them.

The first operation after the writer arrives on a concrete job is to direct the foreman to select a few wheelbarrows of similar shape and equal capacity. In case of a 1:2:4 mixture, a barrel is filled with stone four times on a mixing platform. The stone is again shoveled into the selected wheelbarrows, preferably with straight sides and ends, and note is made of how many wheelbarrows are filled, struck measure, by the four barrels of stone. The same process is gone through in testing capacity for the sand. The contractors generally prefer this method as they can then instruct their men that one batch consists of say six wheelbarrows of stone and three wheelbarrows of sand for each barrel, or four bags, of cement used. In case of dispute or disagreement, then all stone and sand is measured heaped in barrels, as noted by Mr. Gould.

The cement and sand is then mixed dry, not by a prescribed number of turns, but until the pile is of one uniform color. The water is then measured in buckets of known capacity, and the specified number of cubic feet of water per yard of concrete must not be varied unless the materials have become wet from a rain storm or by accident.

The mortar is then made on a mixing platform without sides, two men using rakes or hoes, while the other four men shovel the mixture over until mortar is of a uniform consistency. The stone in the wheelbarrows having been previously drenched and drained no additional water must be allowed. The wheelbarrows are now emptied evenly over the mortar which has been spread over the platform to a depth of 3 ins. The whole mass is now thrown with shovels from the circumference towards the center until a double layer of stone and mortar is formed. The layer is now less in area, but about 12 ins. thick, and uniform, for the rakes are kept continually going as the shovelers throw the material towards the center. The gang is now divided. One half, consisting of two shovelers and one raker, throwing one-half of the pile to right; the other half of the gang throws the material to the left, the rakes moving vigorously all the while to break up any lumps left by the shovels. The rakers now change their positions to the center of the platform, where the two gangs throw their respective portions of the batch. It is again shoveled into two piles and raked, ready to be deposited into iron wheelbarrows with oval bottoms, as such barrows have been found to empty easily and not stick like the wooden ones.

To add water after the stones have been thrown with the mortar invariably leads to trouble.

One reason that accounts for the disrepute into which

many machine mixers have been brought is that the water regulation is defective. The amount of water should be automatically regulated in all mixing machines, and it should be out of the control of the so-called "water tender." In caisson work especially, where large masses may be deposited in one shift, it is necessary that every yard of concrete should have absolutely the same amount of water in the mixture in order to be of the same degree of hardness and strength at the same time.

Mr. Gould must have noticed this defect in machine mixing, for he insists upon the separate dry mixture of the cement and sand before it goes into the machine to meet the stone.

On large concrete works by no means the easiest task for the engineer is to select a machine that is really a concrete mixer and not a separator. Out of all the mixers on the market, the writer knows of only three machines which he could use with results nearly equal to hand mixing, and in these he would require the mortar to be made by hand in every case before throwing it into the machine with the stones.

FIG. 1. CONCRETE MIXING PLANT, ILLINOIS AND MISSISSIPPI CANAL.

I believe that if Mr. McCullough tries the method suggested by Mr. Hammon he will prefer the method of making the wet-mortar before adding the stone.

In so vital a part of a structure as the concrete foundations too great care cannot be given to the manipulation of the ingredients, including the water.

Where the forms are water tight I prefer to have the mixture so wet that it is barely stiff enough to keep the stones from sinking of their own weight. When this is the case there can be no voids. In 1902 about 26,000,000 bbls. of cement were produced in the United States, an increase of more than 6,000,000 bbls. over the previous year. The production of Portland cement has increased thirty-fold during the last ten years.

Besides the plaster and mortar which has been produced from this bulk of cement, the greater portion, it is safe to say, has gone into concrete of various mixtures.

It is well to know which is the proper way to mix this material to get the best results. It has been said that "one test is better than a thousand opinions," and it would be well for a committee to take up this matter jointly with the committee on cement tests.

The effects on concrete, of alternate thawing and freezing; of heating stone, sand or water to abnormally high temperatures before mixing; of adding various quantities of salt to the water in freezing weather, would be interesting subjects for discussion for many of the concrete users who are readers of your paper.

Yours truly, Charles H. Umstead.

Lawrence, Mass., Dec. 28, 1903.

Methods and Cost of Making Concrete for the Headworks of the Feeder for the Illinois & Mississippi Canal.

Sir: In regard to methods of mixing concrete I may be looked upon as a heretic, but if so, I have the consolation of knowing that many good men before me have had the same epithet applied to them.

In 1892 and 1893 I commenced the construction of monolithic concrete on the Illinois & Mississippi Canal, under the direction of Capt. W. L. Marshall, Corps of Engineers, U. S. A. His instructions required a thick layer of facing and of coping consisting of a mortar composed of two parts sand to one part cement, by measure. His instructions also required that the facing and coping mortar, as well as the mass of concrete, be mixed so dry that moisture would show at the surface only under very hard ramming. Labor was plentiful, and, as it was considered that this masonry was to some extent experimental, great pains were taken in the mixing of the mortar, and of the concrete. The mortar was mixed by shovels, first dry and then wet, the water being applied by means of sprinkling cans. When completed the walls presented a fine appearance and, so far as an external examination would show, the mortar was of uniform consistency. It was decided to cut all interior corners of the lock walls to a radius of about 3 ins. A stone cutter was employed for this purpose, and I was much astonished to find that when the mortar was cut into, a large number of hard balls of what appeared to be neat cement, were found in the mortar. All mortar mixed subsequent to that time was thoroughly mixed, and then cast through a screen of ½-in apertures, and the lumps or balls which rolled down the screen were crushed with a shovel on the boards.

After a long experience in the mixing of concrete under a great variety of conditions and with three different types of machines, I have come to the conslusion that the only mixing which is of value is that done when the water is present in the mixture, and when the cement is sufficiently moistened to form an adhesive paste which adheres to the other components of the concrete. I can see no difference in the quality of the concrete due to a different order of placing or mixing the ingredients, but the mixing should always be long enough continued to thoroughly mix the various ingredients. With a machine it is easy to continue the mixing to that point, but when labor is scarce it is almost impossible to secure thorough mixing by hand.

I had an experience with bottomless boxes on contract work once, which led me to prohibit their use, at least so far as measuring the amount of cement was concerned. The contractor first placed the gravel on the board and in the process of filling the boxes with cement, managed to sink the box in the gravel so that less than the required amount of cement was used. There are probably few engineers who would agree with Mr. Gould as to using barrels for proportioning the ingredients for concrete. That method might do for depositing a few yards, but when the quantity of concrete is considerable it would be entirely too slow a process.

The masonry for the headworks of the feeder for the Illinois & Mississippi Canal was built last year, and may be taken as a good example of what may be done in the way of concrete construction under favorable circumstances and with good management. All exposed surfaces of the masonry are faced with a mortar about 1-in. thick consisting of 1 part cement to 2 parts sharp sand. The concrete is composed of 1 part cement, 4½ parts gravel and 4½ parts crushed stone. The gravel consisted of about 50% sharp sand, and 50% pebbles larger than ¼-in. diameter. The gravel was obtained from the canal prism and its cost was the labor of shoveling and hauling to the site of the work by wagon, a distance of about one-half mile. The stone was execavated in the prism near by, partly by steam shovel, and hauled to the crusher by locomotives. Unfortunately the cement was purchased at $2.79 per barrel, delivered, which was at about the apex of the market price for cement. A T. L. Smith ½-yd. mixer was set up in line with the lock wall between the lock chamber and the sluice ways just high enough to permit dumping into a car running on the level of the bottom of the lock walls. By means of a trestle, a charging car could be run out over the mixer and dumped through the bottom into it. The charging car ran under the two small bins and could be filled by means of spouts from them. The stone was not handled after being shoveled into the crusher, being loaded from the bins into cars which dumped into one of the bins over the charging car. The gravel was loaded into cars and dumped into the other bin over the charging car. These bins were adjacent to the ends of a small warehouse, into which cement could be hauled by flat cars. Between the bins was room enough for a small measuring box for the cement, which was on rockers. In the end of the warehouse was a bin with tight floor large enough so that from four to six barrels of cement could be broken into it at once. The charging car was run under the stone bin and receive the proper amount of stone. As it passed outward, the cement was dumped from the charging box and under the gravel bin it received the remainder of the charge. The mixed concrete was dumped into a car which was pushed onto an elevator and hoisted high enough to run over the lock walls. These cars were emptied by means of a 12 x 18-in. opening in the bottom, controlled by a suitable slide. This is an excellent form of concrete car as it permits distribution of the material along the form instead of being dumped into one place to be subsequently distributed by shovel.

The total amount of Portland cement concrete, including concrete in miter sills, which was mixed by hand, is 2,404.7 cu. yds., the total cost being $15,584.80, or a cost per cu. yd. of $6.48. The various items of cost are as follows:

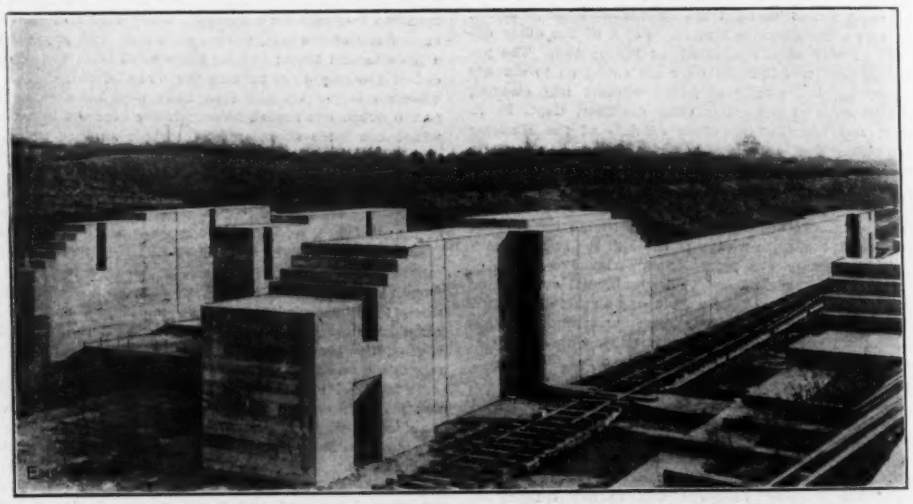


FIG. 2. CONCRETE MASONRY; HEADWORKS OF THE FEEDER FOR THE ILLINOIS AND MISSISSIPPI CANAL.

Labor, mixing and placing	$2,557.89
" carpenter work on forms	1,434.63
" setting up and dismantling machinery	209.49
" building trestles	89.49
" constructing cement shed	49.26
" track work	178.43
" building concrete cars	42.00
" unloading and hauling lumber	177.28
" unloading and hauling cement	137.03
" setting up pump, and pumping	147.34
" miscellaneous	48.95
Coal	162.00
Miscellaneous bills	141.94
1,553 cu. yds. crushed stone	1,360.43
1,600 cu. yds. gravel	870.40
2,571 bbls. of cement	7,173.90
Lumber, 30% first cost	813.34
Total	$15,584.80

It will be seen from the above table that about 1.07 bbls. of cement were used per cu. yd., and that the total amount of ingredients, calling a barrel 3½ cu. ft., amount to 1.45 times the volume of concrete in place. The measurement of gravel and crushed stone delivered was not very accurate. The concrete was deposited at the rate of from 10 to 12 cu. yds. per hour, using about 30 men and boys, all told. Ordinary labor cost $1.75 per eight hours, and carpenters $2.50 per eight hours.

I enclose herewith views, which show the set-up of the mixing machinery, and the finished masonry.

Very respectfully yours,
L. L. Wheeler, M. Am. Soc. C. E.

Sterling, Ill., Dec. 30, 1903.

Some Objections to the Use of Rubble or Boulder Concrete for Thin Walls.

Sir: In reading the specifications for concrete drawn by the "Reclamation Service of U. S. Geological Survey," (Construction News Supplement, Jan. 7), I was pleased to see that the method accorded so closely to that advocated by myself as being one of the best methods, but I cannot help taking exception to the clause which permits the use of boulders, as from experience I have found this to be a frequent cause of failure in otherwise very fair concrete work.

In the first place the use of boulders causes irregularity in shrinkage and even in walls of 2-ft. thickness are a dangerous factor. The only plan under which their use can be considered harmless is in monolithic work such as dams, or foundations which are thick, rather than high.

Then porosity is increased by their use, as the tamping cannot be equal where they are used. The tensile strength is reduced unless the boulders used are stronger than the cement which is not, or has seldom been, the case with any concrete I have had to cut through.

By allowing boulders of the specified size (not more than 1-ft. or less than 6 ins.) to be used "provided that no such stone comes nearer than 2 ins. to the exterior surface of the wall, or to any other boulder or stone so placed," we are simply getting a rubble wall laid in a mortar of broken stone, and not concrete in its best form, to obtain which the stone should be of as nearly uniform size as possible, preferably 2 to 3-in. cubes, or less according to purpose for which used.

As the idea of Engineering News in publishing these letters and specifications is to obtain information upon the subject and not to confirm any one idea, I shall be glad if my contentions are not right to hear from some one whose experience has differed with mine.

I trust also that we may have full particulars of the cause of collapse of the Wing & Bostwick building at Corning, N. Y. I would like to know whether this building was or is of the "wet" concrete-steel construction of which you speak in your editorial in Construction News Supplement of Jan. 7?

I have no doubt that there will be many failures of this class of building, judging from some that I have seen, and which seem to be of the usual and accepted type, but good concrete must not be blamed on this account.

Respectfully yours, Henry G. Hammon.

Oswego, N. Y., Jan. 9, 1904.

[Where a thin wall is made of dry concrete surrounding boulders or rubble stones, it requires great care to prevent the formation of voids; but where the concrete is so wet that the rubble stones almost sink into it by their own weight, and are readily forced down by men jumping upon the stones, there is no danger of porosity in the wall. Thin rubble concrete walls of this kind were described in our issue of June 18, 1903, in an article on the Spier Falls dam. Those walls have proved eminently satisfactory, and it should be noted that the specification of the Reclamation Service calls for similar construction.—Ed.]

COAL AND ASH HANDLING PLANT OF THE NEW YORK RAPID TRANSIT POWER HOUSE.

The accompanying sketch shows the arrangement which has been devised for handling the coal and ashes for the 90,000-HP. power-plant of the New York Rapid Transit Railway. This arrangement is notable for the reason that no elevators are used for any purpose, all material except hot ashes being elevated by means of traveling belt inclines. The sequence of operations can be readily followed by studying the drawing.

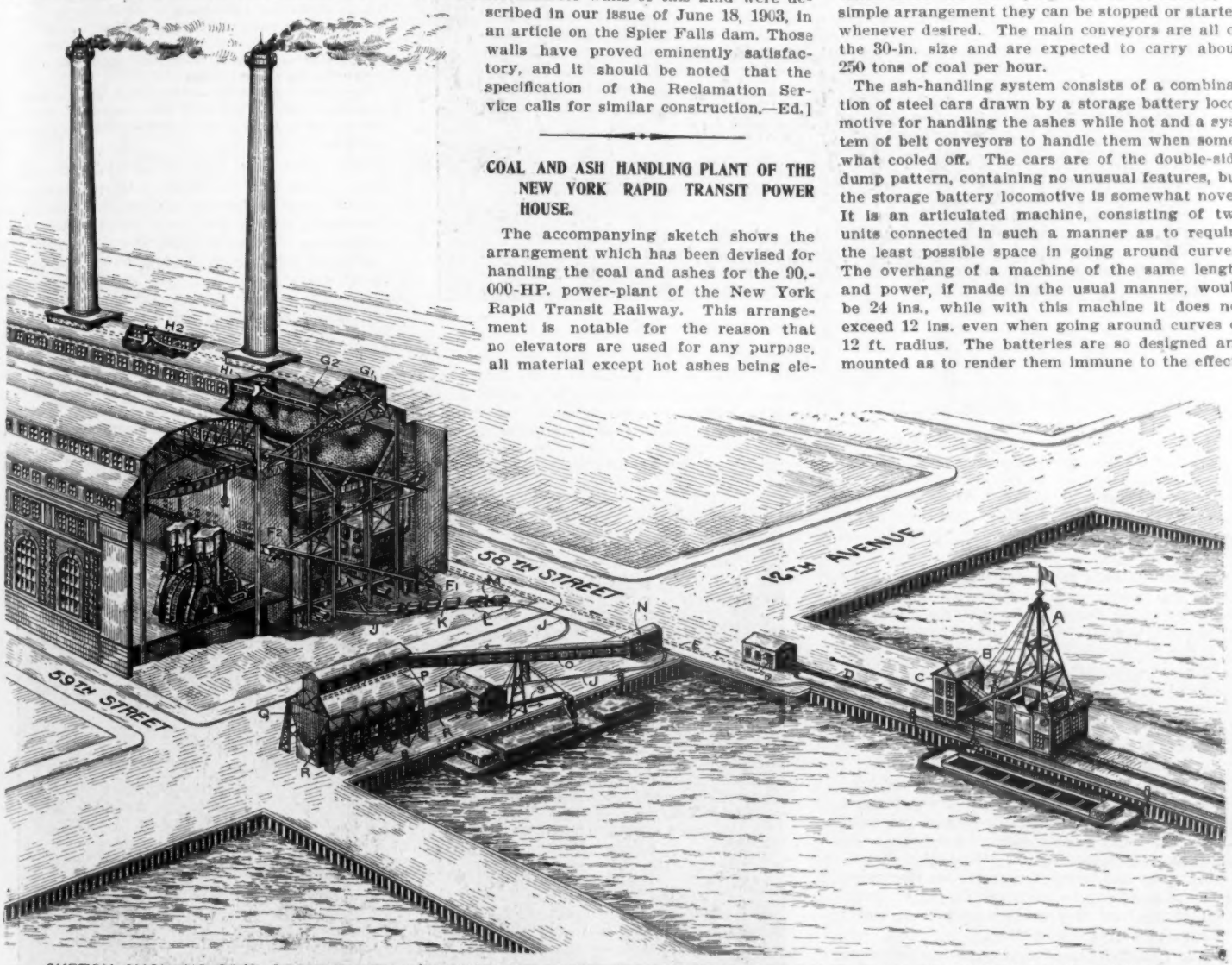
Commencing with the coal as received in barges or schooners, the first operation is the unloading, which is done by means of an electric hoisting tower, with a capacity which is claimed to exceed that of any coal hoist ever built. This large capacity is obtained in two ways: first, by the use of very large and powerful direct-coupled electric hoisting engines with a perfect system of control, and, second, by an arrangement of the tower which greatly reduces the height of hoist. In towers of the usual construction, containing crusher and scales, it is necessary to hoist to about 25 ft. higher than in the present case. In the plant illustrated the weighing is done in a separate building connected with the main tower, the coal being elevated by a belt conveyor from crusher to the automatic scales, made by the Richardson Scale Co. These machines are absolutely automatic, requiring no attention whatever, and they are guaranteed to work well within the allowed variation of one quarter of 1%.

From the scales the coal is delivered to a conveyor on the dock level, which carries it as far as the western side of 12th Ave. At this point it is transferred to an underground conveyor which runs to the western end of the power house. Here, instead of being elevated vertically in the usual manner, the coal is raised by a series of inclined conveyors, which zigzag up the western front of the building until it is delivered at a height of 110 ft. to two conveyors which run lengthwise over the coal bunkers. The trippers for distributing the coal in the bunkers move backward and forward, reversing themselves automatically at each end of their run. The power for moving them is taken from the conveying belt itself, and by a simple arrangement they can be stopped or started whenever desired. The main conveyors are all of the 30-in. size and are expected to carry about 250 tons of coal per hour.

The ash-handling system consists of a combination of steel cars drawn by a storage battery locomotive for handling the ashes while hot and a system of belt conveyors to handle them when somewhat cooled off. The cars are of the double-side dump pattern, containing no unusual features, but the storage battery locomotive is somewhat novel. It is an articulated machine, consisting of two units connected in such a manner as to require the least possible space in going around curves. The overhang of a machine of the same length and power, if made in the usual manner, would be 24 ins., while with this machine it does not exceed 12 ins. even when going around curves of 12 ft. radius. The batteries are so designed and mounted as to render them immune to the effects of jars, leakage and abuse by the operator. The driving gear is simple, and the control is without rheostats, and so located that the operator can run the machine in either direction without changing his position. The motors are entirely supported on springs.

The remainder of the ash-handling system consists of conveyors distributing the coal into a 1,000-ton Berquist patent bunker and loading the ashes into barges.

The entire plant has been designed by the Robins Conveying Belt Co., of New York city, to whom we are indebted for the accompanying



SKETCH SHOWING COAL STORAGE AND ASH HANDLING PLANT FOR THE NEW YORK RAPID TRANSIT RAILWAY POWER HOUSE.

sketch and for the facts from which this description has been prepared.

AN UNUSUAL BRIDGE ACCIDENT.

An arch bridge of rather unusual proportions, now in course of reconstruction at Lockport, N. Y., met with a peculiar accident some weeks ago during the placing of the steelwork. The bridge is a single-span structure crossing the Erie Canal; it is 71 ft. 6 ins. long between end pins and about 250 ft. wide. The main girders are three-hinged arches of solid-web or plate-girder construction, spaced about 12½ ft. apart. Lateral bracing and sway frames connect the girders.

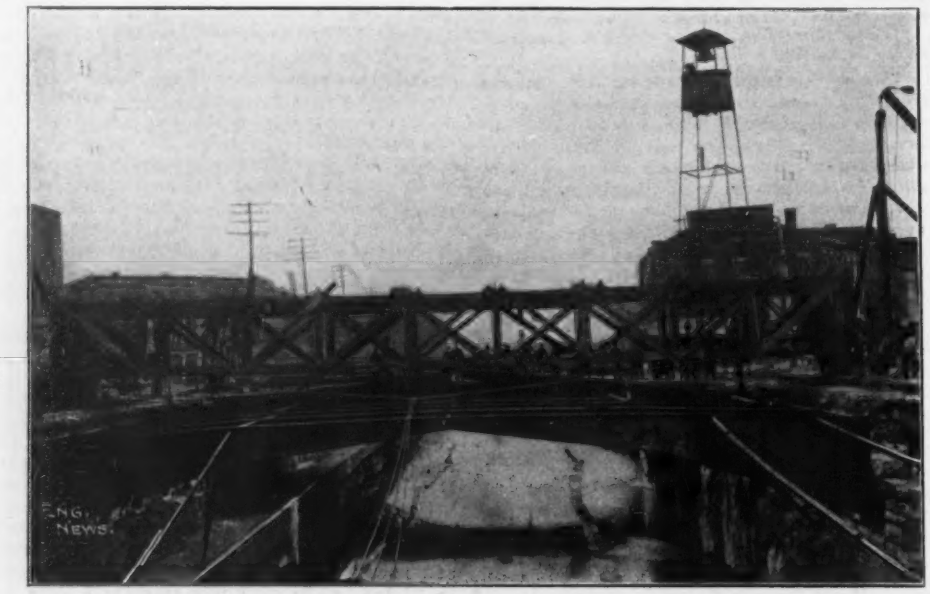


FIG. 1. METHOD OF ERECTING LOCKPORT BRIDGE.

The new work replaces the middle part of an existing bridge, the "Big Bridge," and has the purpose of making provision for running heavier rolling stock over the electric railway tracks of the International Traction Co., which cross over the middle portion of the bridge. The canal at the site of the bridge is in rock cut, with vertical sidewalls.

The method of erection used is shown in the view Fig. 1, accompanying. A wooden truss girder was built across the canal by means of a portion of the old bridge. It was mounted on sliding ways on either bank and served as erection traveler, placing and supporting the work until it could be connected up. A derrick on either bank handled the material to the traveler. Each arch girder of the bridge was received riveted up complete in halves, and was merely set on its end shoes and lowered to bearing against the center pin.

On Dec. 5 when five of the arch girders had been placed in position, the entire group of five dropped at the center and fell into the water of the canal below. The end shoes were disturbed and wrenched loose in most cases. The half arches on the southerly side dropped entirely into the water, while the northerly halves hung on the towpath. Fig. 2 shows how they appeared after the water was drained out of the canal.

It seems that the transverse sway frames at the extreme ends and at points midway between ends and center had been put in place at the time of the fall, but there appears to have been no bracing in a horizontal plane. It is reported that a strong wind was blowing along the canal at the time of the fall, which occurred during the noon hour. The position of the arches and other circumstances indicate that the arches were by some cause forced over sideways sufficiently for the center hinge pressure due to their own weight to slip them off the pins, which would result in their fall. As the sway frames were connected to vertical gusset plates on the girders, this operation would involve only a bending of these plates.

A CALIFORNIA DECISION ON RIGHTS IN PERCOLATING UNDERGROUND WATERS.

The law of percolating underground waters in California was laid down in the latter part of November in a unanimous decision of the State Supreme Court. The decision was given at the close of a rehearing on the reversal of a lower court, the higher court, notwithstanding the mass of new testimony, adhering to its earlier decision. The gist of the decision is that percolating waters are subject to reasonable use no matter if such use interferes with the yield of wells on adjacent property. The facts of the case were: Mrs. Leah J. Katz, of San Bernardino Co., Cal., was enjoying the use of an artesian well when the flow from the well decreased, following the establishment of a flowing well on the adjoining property of Mrs. Margaret D. Walkenshaw. Mrs. Katz brought suit to determine her rights and the courts declared a non-suit. On appeal, a year or so ago, and on the recent rehearing, the State Supreme Court reversed the decision. The non-suit sustained the contention of the defendant that the water from her well was not from a clearly defined stream, but was percolating water and part and parcel of her land, over which she, in common with all others under like conditions, had absolute control, regardless of the effect upon wells in adjacent lands.

In its latest opinion the Supreme Court said, in substance:

This theory, it is claimed, is part of the common law and as such has been adopted in this state as the law of the land. And hence that it is beyond the power of this court to abrogate or change it; that the rule has become a rule of property in this state upon the faith of which enormous investments have been made, and that it should not now be departed from even if erroneous; that even if the question was an open one, the adoption of the doctrine of correlative rights in percolating waters would hinder or prevent all further developments or use of underground water and endanger or destroy developments already made, thus largely restricting the productive capacity and growth of the state, and that therefore sound public policy and regard for the general welfare demand the opposite rule; that the doctrine of reasonable use of percolating water requires an equitable distribution thereof among the different land owners and claimants who might have rights therein, which would throw upon the courts the duty and burden of regulating the use of such waters and the flow of the wells or tunnels and that this would prove a duty impossible of performance; and finally that if this is the rule for percolating waters, it must for the same reason be the law with regard to the abstraction of petroleum from the ground, and if so, it would entirely destroy the oil development and production of this state, and for that reason also that it is against public policy and injurious to the general welfare.

The first contention, namely, that the common law governs, is met by the court with the maxim that where the reasons on which a law is founded fail, the law cannot survive.

The court next pointed out the difference in local conditions in humid England, where the common-law doctrine of underground waters was developed, and in a country where agriculture is practically dependent upon irrigation. Previous decisions relating to underground waters, the court stated, have not been wholly harmonious, nor has the doctrine of absolute ownership of underground water been well established in California. In addition, it was stated that in some Eastern States the rights of adjacent owners have been recognized by the courts when passing upon percolating ground waters. Granted that there is absolute ownership in underground water or oil, one property-owner after another might, in turn, be deprived of the water or oil developed on his property.

FIG. 2. ARCH-GIRDERS OF LOCKPORT BRIDGE AFTER FALL; CANAL DRAINED.

Reasonable use of water will apply, first of all, to some useful purpose on the land from which the water is taken, but a subsequent appropriator may take surplus water for use on distant lands. Where an appropriation or diversion for use on distant lands exists, and land-owners who subsequently wish to use water and find they can-

not do so without restrictions on the distant uses, the court states that it is perhaps best not to lay down a positive rule.

THE YUEN HAN (GRAND TRUNK) RAILWAY OF SOUTH CHINA.

That a standard gage railway having a length of 742 miles is now under construction in China

Fig. 1. Map of the Yuen Han (Grand Trunk) Railway, Located by William Barclay Parsons.

may not be known to many of our readers. Not only is this project of general interest on account of its magnitude, but it is of particluar interest in view of the fact that it is being built with American capital under the direction of American engineers.

The Yuen Han Railway will run almost due north from Canton to Wu-Chang, which is directly across the Yank-Tse Kiang River from Hankau, see Fig. 1. The preliminary location of the route was made by Mr. William Barclay Parson, M. Am. Soc. C. E., now president of the America China Development Co., which is building this trunk line, and has already built a 31-mile branch line from Canton to Sam-sui.

Mr. Parsons began his survey from Hankau, starting with his party late in the year 1898. The line, as run, was 742 miles long, 500 miles of which were through a district that no foreigner had ever seen. The surveyed line was the longest that had ever been run in China. Measurements were made by stadia with a transit having a solar compass attachment, and the final error, as determined by latitude and longitude, was about half a mile, or 1 in 1,500.

The maximum grade is 0.8%, the line for the most part being a river valley location, crossing a divide between the Wu-shin and the Yu-tan-ho rivers, at an altitude of 1,080 ft., through a pass discovered by Mr. Parsons and named after the discoverer. In this connection it is interesting to note that for centuries the Chinese have used a pass, the Cheling pass, some five miles west of the Parsons pass, and 120 ft. higher. Mr. Parsons, in explaining the failure of the Chinese to discover the lower pass, says that a very peculiar rock formation is accountable for a topography that is extremely puzzling. The rock is a soft limestone with "dikes" of a harder limestone, that run east and west. Erosion has cut away the softer limestone, leaving the harder material in the form of ridges that in many places present an almost perpendicular face. There are five of these ridges running east and west directly across the valley, as shown in the profile, Fig. 1. These cross ridges give every appearance of being terminal walls, but upon examination Mr. Parsons found quite a large stream of water gushing from a natural tunnel in the face of the lowest and most southern ridge. Upon tracing this stream northward, it was found that it passed through natural tunnels in the second and third ridges also, finally heading at the foot of the fourth ridge, at an elevation of 1,000 ft. The pass in the fourth ridge itself has an elevation of 1,080 ft., and is therefore 120 ft. lower than the Cheling pass. Thus by tracing the water courses to their springs, Mr. Parsons found that the so-called Cheling pass is in fact a false pass on the flank of a valley that lies in the drainage area of the China sea, and is separateed by a north and south ridge from the true pass over the east and west ridge five miles away.

Some idea of the amount of traffic over the Cheling pass may be had from the photograph, Fig. 2, showing the blocks of stone laid for steps, and from the following description given by Mr. Parsons:

> The central route known as the Cheling is the most important. This route follows the Wu-shwei from Shaschan to the head of small boat navigation, whence there has been constructed a paved highway leading over the range via the Cheling Pass to the head of navigation on the Lei-ho. The length of the highway is about 30 miles. The time when this route was first established, or when and how the highway was first laid out and paved, is quite uncertain. Undoubtedly it is of great antiquity. As a mere trade route, it is probably coeval with the first exchange of commodities between the Yang-tse valley and the region of the China sea. Then, as traffic grew, the land portage was paved, houses for the entertainment of travelers, and for the housing of pack-coolies and ponies, were established. Such houses were, for mutual convenience and protection, grouped into detached villages, and finally these villages grew together, so that the highway became lined with inns, shops and stables almost continuously from end to end. During the two, three or more thousand years of the existence of this route an enormous tonnage, both north and south has passed over it.*

We are indebted to the "China Mail" for the following notes relative to the work of construction:

> The final location of the Yuen Han Railway is now in progress, as is also the construction beginning at the two termini, working both northward and southward. The division work between Canton and Ying Te is well under way, and location parties are in the field working from Wu-Chang southward.
>
> As above stated a branch line from Canton to Sam-sui has already been completed and is in operation. The construction work was at first carried on by native contractors who were so dilatory that the company was finally compelled to take the work into its own hands. Each coolie, man or woman, receives 40 cts. a day and payment is made daily. Barrow pits were made along the road, the material being stiff clay, for the most part, which is built into embankments having 1½ to 1 slopes. The average fill is 3 to 4 ft. above the level of the rice fields, rising to a height of 15 ft. at bridges over rivers. Track is laid with 75-lb. rails, to a gage of 4 ft. 8½ ins. upon steel ties weighing 125 lbs. each. Both ties and rails are imported from Belgium. All the rolling stock will come from America. A number of locomotives, formerly used on the New York city elevated roads, are now in service between Canton and Sam-sui, but the intention is to use 130-ton locomotives and freight cars having a capacity of 80,000 lbs. The bridges are in short spans, being steel girders on concrete abutments, the Portland cement for which is made by the Green Island Cement Co., of Hongkong.
>
> For the protection of the works and the workmen, the company has a uniformed force of 500 soldiers, armed with rifles, but as yet no serious disturbance has occurred. An attack was made upon the surveying party at one time that might have proved serious had the natives known how defenseless the party really was. The party was besieged for several hours in a native temple where they had taken refuge, and their surveying instruments were destroyed. A U. S. gunboat was sent to the rescue and the riot was quelled.
>
> The American-China Development Co. represents American capital, with Mr. William Barclay Parsons, of New York, as President. Mr. Sheng Kung-pas, Director-General of Railways in South China, has appointed Mr. Chun

*From the "Geographical Journal," June, 1902.

Fig. 2. View of the Ancient Cheling Pass, Five Miles West of the New Parsons' Pass.

Ol-ting and Mr. Wong Kok-shun to the Consulting Committee or Directorate. General Whittier, formerly Inspector-General of the 8th U. S. Army Corps in the Philippines, is the Treasurer. Mr. Willis E. Gray is General Manager, with offices in Shang-hai. Capt. C. W. Mead is Chief Engineer, and Mr. Justin Burns is First Assistant Engineer.

The members of the engineering staff on the Canton-Sam-sui branch are: Mr. C. H. Farnham, Division Engineer; Mr. S. T. Neely, Resident Engineer at the Canton Residency; Mr. R. B. Manter, Resident Engineer at the Fatshan Residency, and Mr. C. E. Muller, Resident Engineer at the Chai Bin Residency.

A NEW INTERLOCKING MACHINE; THE PNEUMATIC SIGNAL CO.'S ALL-ELECTRIC MACHINE.

The protection of railway crossings, turnouts, yard-entrances and similar special points by interlocking plants is perhaps the most important single branch of railway signaling. The fact that many states of the Union have passed laws requiring grade-crossings of railways to be equipped with interlocking plants, while no laws exist (to our knowledge) for the compulsory installation of line signals, points to this conclusion.

As a natural result, interlocking as a separate branch of the signaling art, has become highly developed. In part, this development has followed that of line-signaling. The earliest interlocking machines were manual machines; that is, they consisted of levers linked directly to the operating rods of the signals and switches by means of wire or pipe connections. This class of machine is still widely used. Parallel with the introduction of pneumatic operation of signals, various forms of pneumatic interlocking machines were developed, in which the levers thrown by the operator did not actuate the switches and signals directly, but merely set the valves which controlled their movement. More recently electric motors have been

used to operate line signals, and correspondingly there has been developed a type of interlocking machine, the so-called all-electric machine, in which the levers act to make and break the circuits operating these motors. In all these machines the actual interlocking mechanism has remained practically the same as that applied to the earliest machines—a mechanical arrangement

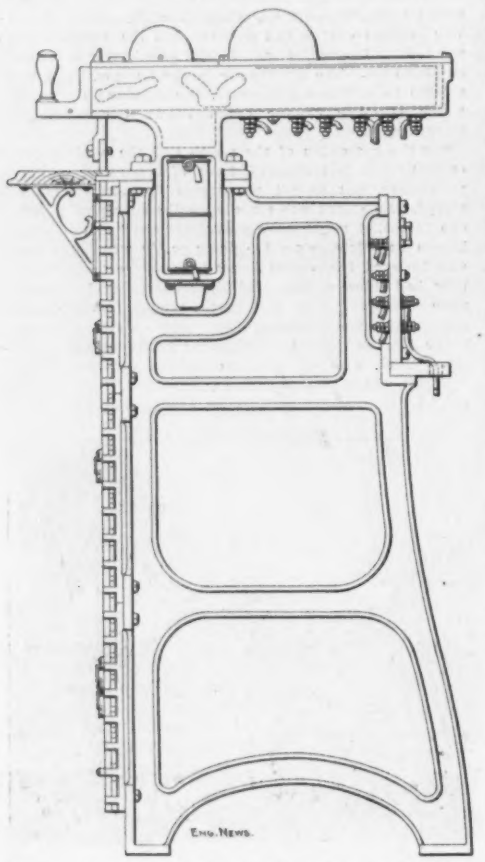


Fig. 1. Side Elevation of All-Electric Interlocking Machine.

of notched slide-plates and dogs adapted to lock any given lever in one position until all levers which control conflicting switches or signals are properly shifted to make the desired movement safe.

An all-electric interlocking machine which has been perfected very recently and is just being introduced is described in the following. It is made by the Pneumatic Signal Co., of Rochester, N. Y.; the same company has also designed a motor-operated switch mechanism and a motor-operated semaphore signal which complete the all-electric interlocking equipment. A side elevation of the machine is shown in Fig. 1, and the construction of the lever and its contacts is more clearly shown in Fig. 2, a transverse section of the top of the machine. The half-tone view, Fig. 3, reproduces a photograph of a large (56-lever) machine of this kind.

The levers grouped at the top of the machine make the contacts to start the switch or signal motors. Each lever has two positions: The "normal" position, as shown in the drawings, and the "reversed" position, or lever pulled out. In pulling the lever to "reversed," an inclined slot in the front portion of the lever engages a roller on the upper end of the tappet-rod, A, and thereby raises this rod. The arrangement of notches in the tappet-rods of the various levers, and of the horizontal slide-plates and dogs which effect the interlocking of the levers, is the same as in other forms of interlocking machine, except for minor variations in details.

An important point to note is the following: As in other interlocking machines, while the lever is in the first part of its motion it raises the tappet only half way, thereby locking all levers which conflict with the new position of the lever, but not unlocking the levers conflicting with the old position; in this part of its motion the lever makes the necessary contacts for effecting the desired switch or signal movement. The lever is held in this half-way position by a latch, until the desired movement has been properly completed; when so completed, a return impulse or "indication" is sent back over the connecting wires to the lever, and this indication not only releases the latch of the lever, but automatically completes the lever's motion. This "automatic stroke completing" feature is peculiar to the machine being described. The levers conflicting with the former position are, of course, unlocked as the stroke is automatically completed.

The mechanism of the lever comprises (1) the lever and the attached interlocking arrangement; (2) electric contacts for making the proper connections to operate the switch or signal belonging to that lever; (3) the combined indication release and automatic stroke completer; (4) a set of safety contacts which prevent improper motion of the switch or signal by stray currents. In Fig. 1 the interlocking mechanism, which differs only in minor details from the usual forms, is shown at the left, occupying the front of the machine; it need not be further described. The levers are at the top of the machine; their construction will appear from Fig 2, where are shown the contacts, latch mechanism, and automatic stroke completer of one lever. The particular lever shown is a lever governing a switch; the signal levers are somewhat simpler in arrangement.

Each lever and its enclosing casing constitutes a separate section, which is fastened to the frame by the two main bolts indicated in Fig. 2. The casing section contains an electromagnet, B, and three double sets of contact springs, I, O and S. The lever itself has two curved slots, C and D, one actuating the vertical tappet-bar, A, while the other engages the armature of electromagnet, B. The rear section of the lever carries contact strips adapted to close the circuits of the springs, O_1 O_2, S_1 and S_2, and also has two projecting pins for throwing a T-shaped knife-switch W, arranged to close the circuit of either I_1 or I_2.

The contacts, O_1 and O_2, are the operating contacts, which close the circuit through the switch-motor, for either normal or reverse rotation. The field-winding of the motor is double, in opposite directions; one winding is connected to the contacts, O_1, the other to O_2, so that the proper motion of the lever, inward or outward, serves to start the motor running either normal or reversed, i. e., to open or close the switch, or vice versa. When the switch has completed its movement, it makes a contact which sends back current through a separate wire, the indicating wire, to one of the two sets of contact springs, I_1 and I_2, and thence through the windings of magnet B. The magnet being thus energized, it attracts its armature upward, and by forcing the roller against the inclined part of the slot in the lever it completes the stroke of the latter. During this latter movement a pin on the lever engages the stem of the knife-switch, W, and throws it over to the opposite position, thereby breaking the indicator circuit.

To make the action of the machine clearer, it is necessary to describe briefly the construction of the switch mechanism. This is shown in Fig. 4 in two views, one with the enclosing cover in place, the other with cover removed. The mechanism comprises a series-wound (direct-current) motor, and suitable gearing which drives the main pinion. A rack linked to the switch-rod engages this pinion and is driven by it. The motor and gearing are connected together not rigidly, but by a magnetic clutch, energized by the main motor current. Above the rack-bar is mounted a double knife-switch, which is operated by a pin on the rack-bar. This knife-switch makes or breaks the main motor circuit. It has two sets of contacts, one connected to each of the two field-windings of the motor, and also leading back by way of the two operating wires to the contacts O_1 and O_2, on the lever of the interlocking machine. When the mechanism is at rest, one of the contacts is open, the other closed. As soon as the rack begins to move, the open contact is closed, but this has no effect upon the motor since the corresponding operating-circuit is open at the lever of the machine. When the switch-mechanism has just completed its movement, it opens the second contact, and thereby breaks the circuit of both motor and magnetic clutch. The motor then comes to rest by running free, and the mechanism is in position to operate in the reverse direction when the lever at the machine is moved.

In addition to this motor-circuit knife-switch, there are two sets of contacts for the two indicating wires leading back to the springs I_1 and

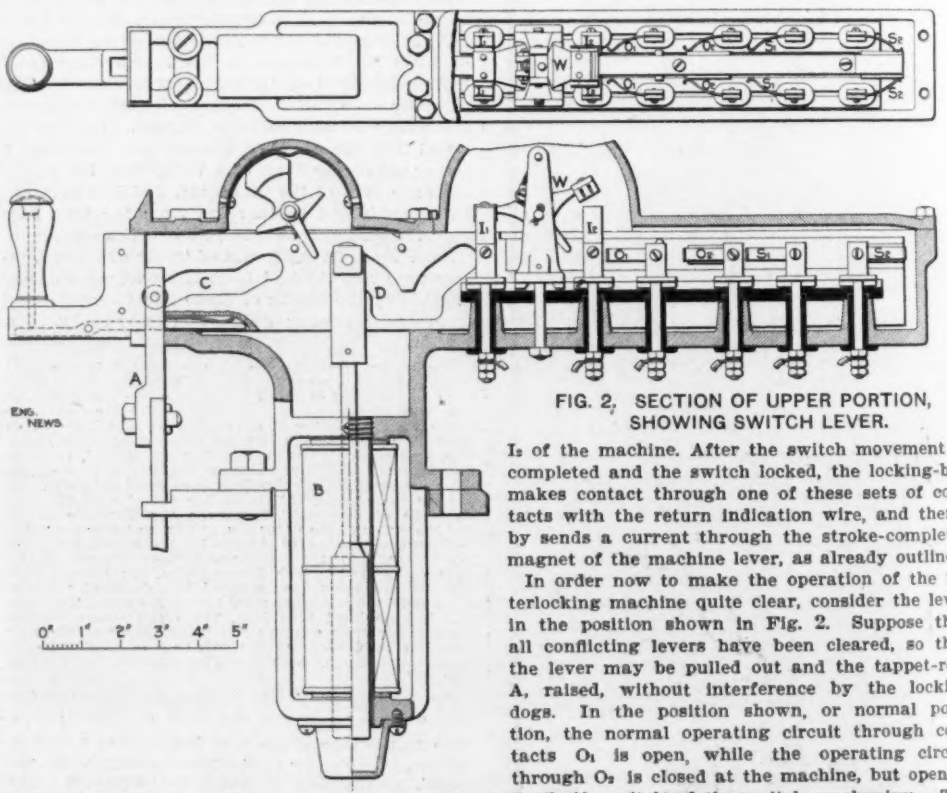


FIG. 2, SECTION OF UPPER PORTION, SHOWING SWITCH LEVER.

I_2 of the machine. After the switch movement is completed and the switch locked, the locking-bar makes contact through one of these sets of contacts with the return indication wire, and thereby sends a current through the stroke-completer magnet of the machine lever, as already outlined.

In order now to make the operation of the interlocking machine quite clear, consider the lever in the position shown in Fig. 2. Suppose that all conflicting levers have been cleared, so that the lever may be pulled out and the tappet-rod, A, raised, without interference by the locking dogs. In the position shown, or normal position, the normal operating circuit through contacts O_1 is open, while the operating circuit through O_2 is closed at the machine, but open at the knife switch of the switch mechanism. The indication contact I_1 is closed at the lever, but open at the switch-mechanism. We need not consider at present the function of the safety contacts, S.

The lever is now pulled out as far as it will go. The magnet B being unenergized, the slot D presses down the magnet armature, until its roller bears against the vertical face of the slot just be-

yond the middle. The lever can now be moved no farther. In this motion the tappet A has been raised into the straight part of the slot C. This movement locks all levers conflicting with the desired movement. The motion of the lever has also opened the circuit through operating contacts O_2 and closed circuit through contacts O_1. These latter now supply current from the busbars of the machine to the operating circuit of the switch motor; the motor starts and is connected to the gearing by the magnetic clutch. As soon as the rack-bar of the switch mechanism begins to move, it closes the reverse operating circuit corresponding to O_2, but it will be noted that contacts O_2 are now open, so that the motor continues running. When the switch movement is completed the circuit through O_1 is broken at the switch mechanism, and the motor stops. At the same time the lock rod of the switch closes the indication circuit corresponding to I_2, and thereby allows current from the busbars to flow through I_2 and thence through the windings of the magnet B. The latter attracts its armature upward and forces the roller at its upper end against the inclined part of slot D, thus forcing the lever to the left and completing the stroke.

While completing its stroke the lever performs two functions: (1) It throws the indication knife switch W so as to break circuit through I_2 and close circuit through I_1. Since the circuit of I_1 is open at the switch mechanism, this operation de-energizes magnet B, but leaves the contacts properly set for the reverse operation. (2) It raises the tappet bar A through the remaining distance, and thereby unlocks all levers conflicting with the previous position of the lever. This finally completes the movement.

The safety contacts S_1 and S_2 at the lever are intended to protect the apparatus from unauthorized operation by stray currents. In order to have an unauthorized movement of the switch (or signal) controlled by the lever in question, positive current from some source must be applied to its operating wire. When the lever is in normal position, for example, as in Fig. 2, a current would need to be impressed on the reverse operating wire, which is connected to contact spring O_2. The safety contact S_2 is connected to the common negative wire leading from the switch mechanism to the machine, and if any positive current reached the reverse operating circuit O_2, it would be short-circuited through S_2 and would blow the fuse (mounted on the machine terminal board) in that wire.

A crossed wire in the indication circuit is fully provided against by the arrangement of the indicating contacts. When the lever is in normal position, the reverse indication circuit through I_1 is closed at the lever, so that any cause sending a false indication over this wire would energize magnet B and thus lock the lever in position until the cross was remedied.

A special feature of the machine is the mechanical latch shown at the left end of the lever, Fig. 2. This acts to prevent the lever, when in reverse position, from being returned to normal unless the button on the handle is pressed down. Thus it is impossible for a casual push against the lever to effect an unintended movement.

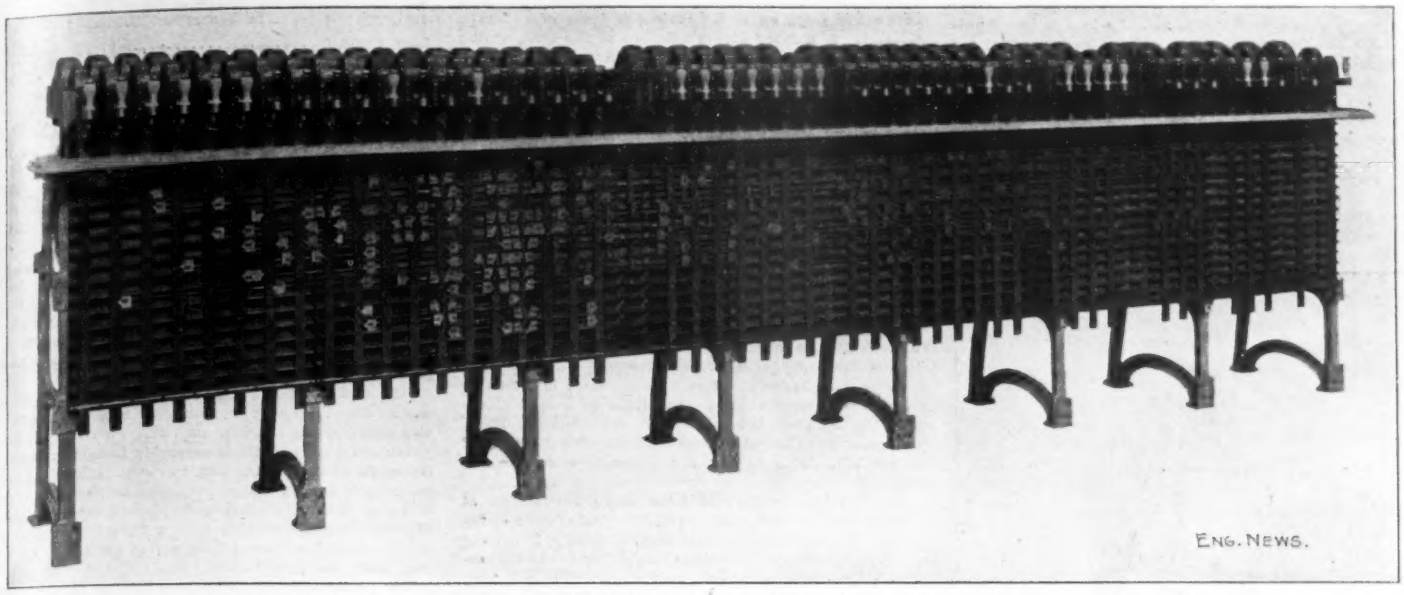


FIG. 3. VIEW OF 56-LEVER ALL-ELECTR.C INTERLOCKING MACHINE FOR TEXAS PACIFIC RY., AT TEXARKANA, TEX.
Built by Pneumatic Signal Co., Rochester, N. Y.

The interlocking machine has a slate terminal board at the back, as may be seen in Fig. 1. The wires from the contact springs in the levers are connected to the back of this board, while at the front are connected the wires leading out to the switches and signals. The positive wire of each lever is provided with a glass-incased fuse.

The indication magnet has a lift of 1 3-16-in. In completing the lever stroke it moves the lever 1 in., and is capable of lifting a weight of 20 lbs. on the tappet jaw. The windings of the magnet have a resistance of 50 ohms, and take about

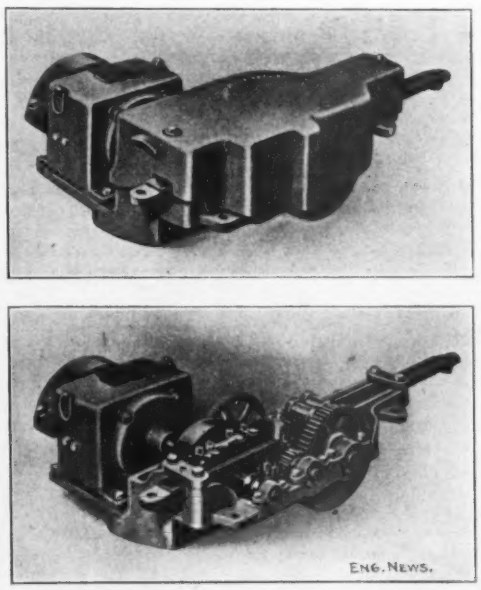


Fig. 4. Two Views of Switch Mechanism of All-Electric System, with Cover in Place and Cover Removed.

2 amperes; this current is used for only a fractional part of a second.

The levers in the machine are spaced 3 ins. apart. The extreme width of the machine front to back is 25 ins. Its length, and the height of the locking plate, of course vary with the individual case. A particular feature of the machine is that one lever can be used to operate a cross-over, or two or more switches, as may be possible with the individual track layout. This feature permits of reducing the number of levers to a minimum. When operating more than one switch from the same lever, the switches work in series: the operating wire from the lever goes to the first switch; the indicating circuit from this switch is the operating circuit of the next, and so on; the indication from the last switch of the series goes to the machine. When the lever is moved, the first switch is thrown, then the second, etc., until finally, when the last one is thrown and locked, it sends the indication impulse to the machine and completes the stroke of the lever.

From the foregoing description the circuits easily follow. For every function to be performed a separate wire is used. For example, to a switch there is one normal operating wire and a reverse operating wire, a normal indicating wire and a reverse indicating wire. For a signal there is a reverse operating wire and an indicating wire. If it is a selected signal there is a separate wire to each selector magnet of the signal from the selector. A common wire, which for convenience is usually termed a "negative common," is run to each switch or signal and permanently attached to one pole of its motor or solenoid (the dwarf signals used in this system are operated by solenoids). This "common" serves for the indicating as well as the operating circuit.

As has already been noted, the signal levers of this machine are slightly simpler than the switch levers, and the signal wiring is also more simple. The signal lever has only the indicating, one operating and one safety switch, and the indication slot D is modified by widening out the right-hand half of the slot, since only one indication is used. The form of signal-arm mechanism used is shown in the half-tone view Fig. 5, as fitted in the base of the signal mast.

In connection with Fig. 3, showing a 56-lever machine of this kind as built, we present in Fig. 6 a plan of the crossing for which this machine is intended. It is on the Texas & Pacific Ry., at Texarkana, Tex. The plan shows the location of all signals, switches, derails and scotch-blocks used to protect the combination crossings and turnouts. Each switch is fitted with a detector bar, as usual, and the crossings are similarly provided. The detector bars have been omitted from our plan for the sake of greater clearness.

OPPORTUNITIES FOR THE CHEMICAL ENGINEER IN THE CERAMIC INDUSTRY.*

By Edward Orton, Jr., E. M.†

Portland cement, of a sort, has been made in this country for many years. But the manufacture of real Port-

*Extracts from a paper published in the "Bulletin of the University of Wisconsin," No. 83.

†Director and Professor of Department of Clay Working and Ceramics, State University, Columbus, O; also Secretary American Ceramic Society.

land cement, whose composition is the result of accurately controlled synthetic chemical processes, is very young. Only fifteen or twenty years have passed since this work began to take root here. Only ten or twelve years have passed since the home product began to become a factor in our supply. It is only three or four years since our production outstripped foreign importation. And yet, what a lusty young giant our Portland cement industry has become. Plants have sprung up like mushrooms, not in one state, but all over the union. Cement is being produced at unheard of costs and sold for purposes that ten years ago could not have been considered for a moment. Our production doubles every year or two and our consumption keeps pace. Portland cement manufacture, as practiced in America, is probably the most magnificent illustration of the production of a strictly homogeneous chemical product on a vast scale. A good cement should not vary more than ½% in alumina, 1% in silica, or 1% in lime. The crude rocks and clays from which it is made are constantly fluctuating in their proportions. Nevertheless, we are producing 1,000 bbls., 2,000 bbls., and

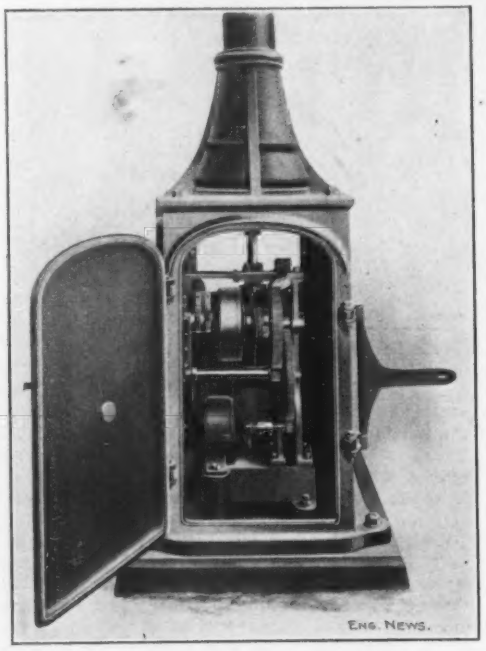


Fig. 5. View of Lower Portion of Signal Mast, Showing Operating Mechanism.

even 4,000 bbls. in 24 hours from a single works, without exceeding these proportions in one single barrel, and Edison is now preparing to make 10,000 bbls. a day. It is a superb feat. Chemical control of every car load, of every stock bin, of every conveyor, of every tube mill from end to end of the process is the absolute prerequisite. With such chemical control established, the mechanical problem of increasing the quantity is simple—it merely means more units of every sort of machine and apparatus.

The typical American plant, with its wealth of pre-grinding and pre-averaging machinery, its rotary kilns, its powdered fuel plant, its cooling bins, its grinding apparatus, and its ageing bins, represents at the present time a fair and characteristic example of American technology. We have in twenty years developed the finest mechanical system for accomplishing in turn the various chemical and physical processes of cement manufacture; we have produced the finest kiln for accurately controlling the critical burning process; we have built the most enormous plants, and attained the greatest daily output; we have come from nothing to be the second largest factor in the cement trade in the world, and soon we will stand at the head. All this is very gratifying to our self love, but let us look for a moment at the other end of the story.

What is Portland cement? Roughly speaking, it is a vitrified silicate and aluminate of calcium, fluctuating between certain narrow limits of composition. Accurately speaking, we do not know what it is. We do not know what silicate is formed in its vitrification, nor what salts are formed when it hydrates. We know only that a highly basic unstable compound becomes fairly stable by hydration, and that a silicate of calcium and an excess of crystallized calcium hydroxide seem to be among its components. We produce six or eight million barrels a year, but we have produced scarcely a single investigator who has contributed anything noteworthy to the knowledge of cements.

But, what are the American chemists doing, you ask? Making cement. The cement men seem to be engaged in a ceaseless struggle to decrease cost, to increase output, to make more money, and only take such casual note of improving the character of their output as their trade actually demands.

It is a significant fact that scarcely a single contribution of importance to our higher knowledge of cement has yet come from America. One poorly conceived, poorly executed, and entirely inconclusive series of experiments was published by an American about ten years ago, and for lack of better material has been industriously copied by every English-speaking writer since.

Our trade literature also is similarly deficient. We have not a single technical journal in English which tells us what is going on in the centers of study of hydraulic silicates. A number of journals are in the field, giving every little scrap of news on the commercial and mechanical side, but they are absolutely barren as respects chemical research.

What, then, are we to conclude from this hasty view of the Portland cement industry. Is it an exact science, or is it coming to be one? As we have pointed out, it is one of the best demonstrations of exact chemical control on a gigantic scale. It is equally gratifying from the point of view of the mechanic. What then is its weak spot?

In my opinion, it is the lack of proper training for the business. Our cement plants are driven by two sets of have a period of regeneration to go through. Their pressmen. Sometimes one, sometimes the other is in charge. Generally both are to be found in every plant. They are respectively the mechanical engineer and the chemist. Neither has been trained for his present work. Both take it up bravely, and succeed as we have seen, to a notable degree along certain lines. But there is a lack of cooperation between these physical and chemical ideas. Neither can wholly put himself in the other's place. And as we have seen, neither can succeed, when working alone.

The American cement industry needs two things at present, before it can expect to win the choice trade of the world. We may undersell Germany, if quality is not absolutely imperative. But where realiability is the first essential, the Germans have us on the hip. We need, first, men who enter the cement business, trained thoroughly in both roles—the chemistry of the silicates, and mechanical engineering. It is too much to expect that the ordinary B. Sc. who steps from school into a cement plant can do more than keep his head out of water. He has had so much to do in other lines that he cannot be expected to be familiar with silicate chemistry, a line by itself. In addition, how many of our college graduates are sound in the fundamentals of mechanical engineering? The mechanical engineer is equally helpless. He has probably had some chemistry in his freshman year, and may even have had a little laboratory work in his sophomore year, but chemistry has generally become very hazy to him by the time he graduates. Both men are apt to stick to their daily task, and use their full efforts to make their part successful. But neither is in a position to supply the master hand, and with a comprehension of both sides of the problem, take the initiative that is so badly needed.

We need, second, a finely equipped and well managed experimental laboratory for the cement industry. It should be equipped with a miniature works, prepared to make cement by the ton if necessary. It should be supported, preferably, by the cement makers in co-operation, and each should be able to have his problems studied by men who know how to do such work. Cement chemists trained in a few months in such a place, get a graduate course which would double their value to their employer.

FUTURE OF THE AMERICAN CERAMIC INDUSTRIES.—The ceramic industries are of vast extent. Few vast, few realize. The figures for 1900 show:

Clay products	95½ million dollars
Glass products	56½ million dollars
Cement (not including lime)	13½ million dollars
	165½ million dollars

These figures are now much too small; probably 200 million dollars represents the output of the current year. When it is know nthat the total fuel production of the United States in 1900 was only about 400 million dollars in value, and the total production of crude metals, excluding the money metals, gold and silver, was about the same amount, the position and standing of ceramics compared with metallurgy may be better appreciated. Further, they are destined to have an enormous expansion in the near future. Lumber is being rapidly depleted, and iron is always more expensive than clay and cement. In the next two decades the ceramic industries will outstrip all other branches of the constructive art in proportionate growth.

THE CERAMIC INDUSTRIES AS A FIELD FOR ENGINEERS.—The ceramic industries need engineers. It has been shown, I think, that their work is of a sort which admits of scientific control. In fact, in instances, it is already on that basis. But, as a whole, these industries ent leaders are gradually awakening to that fact. As a rule they realize only faintly how much they are in need of technical aid. But they show a more mellow frame of mind and lend a more willing ear to the advice of technical men than ever before.

The young man who goes out to seek his fortune in this field of engineering must confidently expect that his path will be a rough one. He has the path of the pioneer to tread. His task will be not only to see the defects of existing methods and to find a way to improve on them, but also to gain the confidence of the present owners and managers, and through them accomplish the necessary reforms.

In civil engineering, mechanical and electrical engineering, mining engineering, and architecture, young men of college training are no longer an experiment. They have been tried and have demonstrated that as a rule they can give a fair account of themselves, and that they can earn a moderate salary from the start. A young man preparing for those lines of engineering is moderately sure of a good chance. His ultimate success will depend only on his competence. He may also be equally sure that he will have plenty of competition and that he is not likely to progress fast except by showing unusual ability.

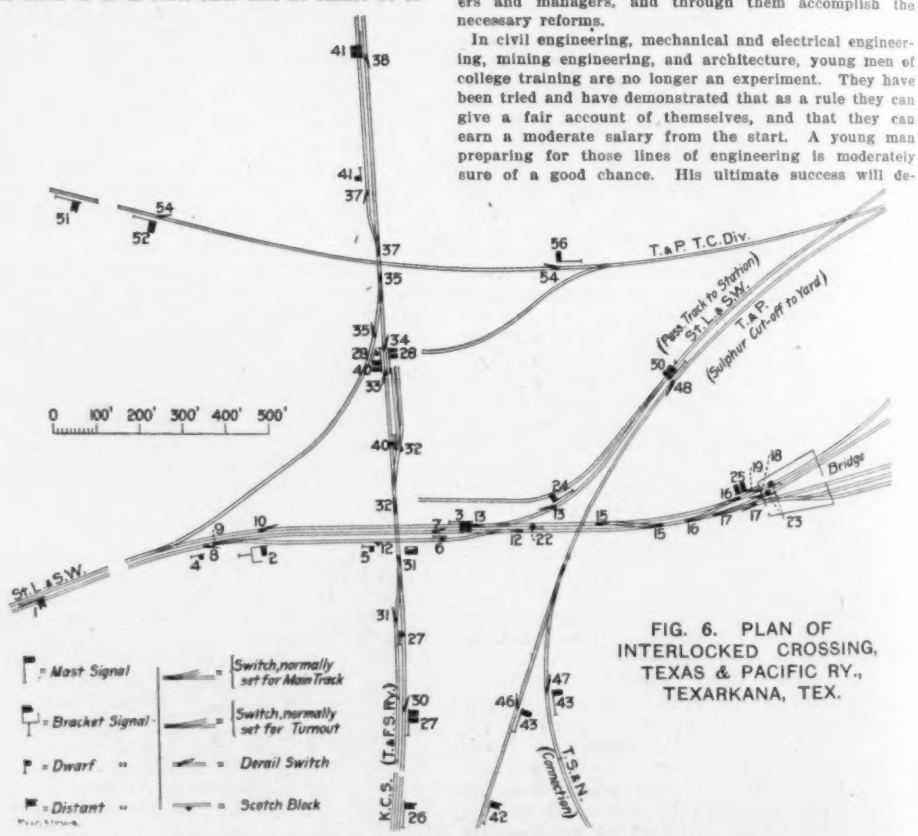


FIG. 6. PLAN OF INTERLOCKED CROSSING, TEXAS & PACIFIC RY., TEXARKANA, TEX.

But in this field which has been presented, things have not yet reached that point. Your first struggle may be to show that you are not a conceited fool, as the average practical man in the ceramic industry will be sure to believe. The practical man is apt to be surprised if the young ceramic engineer can demonstrate to him that he has as much grit and muscle and patience and common sense as any other young fellow whom he might hire. Next comes the much harder position of making him see that while you have not his practical experience you can see some things that he cannot, and that this knowledge

gives you an advantage over him. When you have gotten this far your case is won. He will forthwith fly to the other extreme, and, assuming that you know much more than you do, will pile on duties and responsibilities faster than you can assimilate them.

In all sincerity I may say that I regard this field as the best one for the young engineer to-day. It has greatest possibilities. It is least crowded. If success is reached it will lead to quicker fortune than almost any other, and, better still, it offers the chances for greatest service to mankind. But, on the other hand, it will require men of larger mold, of greater tact, of more unselfish devotion to the cause of wider preparation than other engineering professions in which the routes to success have already been well trodden. It requires the pioneer, and pioneers must always be exceptional men.

A word as to the kind of training needed. It has already been stated that the ceramic engineer must be fundamentally a chemist. He stands just where the mining engineer does in this respect. Both professions are really chemical engineering. One deals with the metals—the other with the silicates. Both differ from that which is commonly called chemical engineering, in the fact that they deal with a less extended range of industries, that their work is wholly inorganic and principally pyro-chemical, and that their products are usually on a much larger scale.

It has also been stated that the ceramic student should master the chemistry of the silicates. This is not easy to do, because it is not now generally taught as a specialty. But in most schools it can be culled out from other general chemical work by the student who searches for it. And, as time goes on, schools will offer more in this line. In the chemical technology of the clay, glass and cement industry, a well trained chemical student should spend two years at least to get a fair idea of what has already been done.

These recommendations will surely awaken dispute among educators, in so far as they receive any attention, for there are many who do not believe in the specialization of engineering courses. The cry of over-specialization has been long and loud in recent years. But there are special courses and special courses. In some the idea is to teach the student just such little fragments of knowledge as will enable him to do one specific thing without care or thought as to his intellectual future. Such courses are short, narrow, and thoroughly objectionable. But in the kind of special course which I am advocating the specialization is mainly in the specific aim which animates the student throughout his work. It is fully as long, fully as thorough, and fully as broad as any other. It should be longer and broader, because the student is expected to add his specialty to a sound course in engineering—not subtract it from it.

But some educators object to the idea of making the end of education specific. They think that the student cannot become broad while becoming a specialist, and that his course should at the end leave him free and unbiased in his choice of life. My view of this point is that the engineer is not made by pursuing any fixed list of studies. It is the way he studies, rather than the thing he studies, which makes him a man. They produced engineers years ago, when a little surveying and astronomy was about the limit of the technical work offered in schools—all the rest was the old time academic training, and these old engineers set their mark so high that the following generation found it difficult enough to reach it. A technical course, no matter how special it may be, if it is long enough and well taught and well studied, has, in my judgment, the very highest educational value. It makes no difference what its goal may be. The one necessary and important condition of success in education is interest. Interest your man, and you educate him—without interest any education is superficial and fleeting. The more general the course, the less hold does it lay on the interest of the student. Preparing one's self on general principles, to meet conditions which may never arise, may commend itself to some systems of pedagogy, but not to mine. Mr. Dooley was partly right when he said, "It don't make much differ what ye tache a boy, so its somethin' onpleasant."

And, when a boy has, through the stern discipline of the special course, finally emerged from his period of study and comes to measure up with his colleagues, where will he stand? He may lack breadth of general knowledge—not necessarily. He may lack polish—not necessarily. But he has the better education of the two, for he has deep and vital interests, and an intense desire for competence in his line at any cost. For it, he has gone through all tasks, whether he could see their utility or not, and for it he will go on as far as the widening vistas of knowledge may lead him.

METHODS OF MEASURING THE FLOW OF STREAMS.

By John C. Hoyt.*

In 1888 the U. S. Geological Survey started to make systematic measurements of the flow of the principal rivers in the United States. Prior to this date the methods used by engineers in stream measurements consisted in measuring by elaborate methods, and, as a rule, at considerable cost, the flow during limited periods. No effort was made to collect data from which the total flow or its seasonal distribution could be determined. The impracticability of this plan is quite apparent when one considers that the stage in most rivers, which is one of the principal factors in determining discharge, is continually changing and that this change is brought about by climatic and other conditions which follow no general law. Periods of extreme low and high water are liable to occur only once in several years, and it is very seldom that the aggregate flow for any two years is the same.

In view of these conditions it was contended by the Survey that a method should be devised whereby the observations should be so distributed and of such nature that from them the daily flow for long periods could be estimated; thus supplying data from which a reasonable estimate could be made of the conditions to be expected in future years.

A careful analysis of the conditions showed that to determine the flow of a stream during a given period two principal factors are necessary. First, the daily gage heights of the river referred to some arbitrary datum; and second, the discharge in cubic feet per second (sec.-ft.) at various stages. With these and the fundamental assumption that the discharge is a function of the gage height and that like gage heights will have like discharges, it is possible to prepare a rating table which gives the discharge to correspond to each stage of the river as shown by the gage.

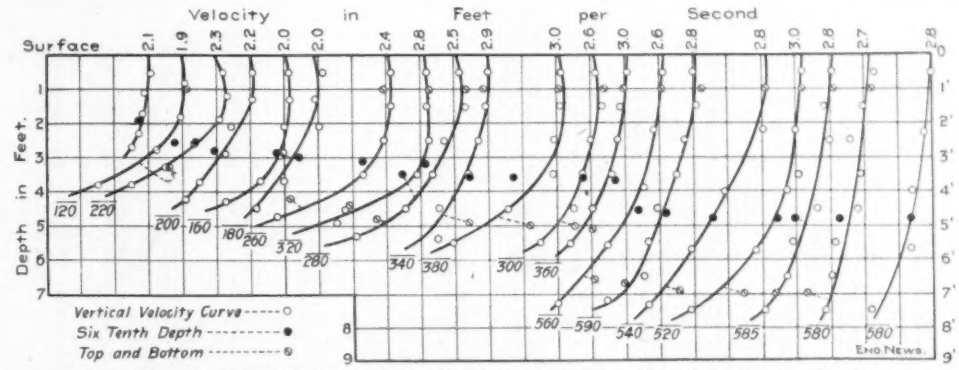
With the idea of constructing this rating table, discharge measurements are made at typical stages. These discharges are plotted as abscissas and the gage heights as ordinates. Through these points the curve of discharge is drawn and the rating table is taken from this curve and smoothed out by differences. By entering the rating table with gage heights the daily discharges are determined. These observations at most stations are continued for a series of several years, thus furnishing engineers and others who are contemplating hydraulic constructions sufficient data to determine what conditions may be expected on the streams in question.

After selecting a suitable gaging station the method pursued in making a single discharge measurement is to lay off on a line perpendicular to the current an arbitrary number of measuring points. These points are, as far as practicable, at equal intervals, and they are sufficiently close to each other so that the soundings at them will develop the cross-section of the stream and give sufficient data for computing the partial areas of the cross-section. These areas are the first factors in the measurement; the second factor is the velocity, which is determined by a current meter in the vertical at each point. It is assumed that each velocity so determined is the mean velocity for that portion of the stream in the immediate vicinity of the perpendicular dropped from the point. The product of these two factors gives the discharge for the portion of the stream in question, and the total discharge for the stream is the sum of the discharges of these partial areas. By this system of partial discharge, local conditions are not distributed to parts of the stream in which they do not apply.

In these measurements the principal factor to be determined is the velocity. In the consideration of this subject much thought and time has been given, which has resulted in the development of four methods which are now in general use. These methods are as follows:

(1) The vertical velocity curve;
(2) the single point method;
(3) top and bottom method;
(4) vertical integration method.

In determining velocity by the vertical velocity method, a series of velocities are measured at several points in the same vertical; these are plotted on cross-section paper and the mean velocity for this vertical is found either by dividing the area enclosed by the curve through these points by the depth, or by dividing the area into a number of horizontal sections of equal height and taking the mean of the abscissas of the middle of these horizontal sections for the mean velocity. This method is the standard by which other methods are compared; by it is determined the depth at which the thread of mean velocity occurs, and also the coefficient used in reducing the other methods. Owing to the length of time taken in making these measurements, they are used only as checks and to determine coefficients.



VERTICAL VELOCITY CURVES FOR SUSQUEHANNA RIVER AT HARRISBURG, PA., NOVEMBER 2, 1903.

In the single point method the velocity is determined at only one point in the vertical, this being either an arbitrary point, for which the coefficient to reduce to mean velocity has been determined, or at the point which lies in the thread of mean velocity. The distance below the surface of this point has been found to be approximately 0.6 the depth of the stream. It is by this method that most velocity measurements are made, when the velocity is small enough to allow the meter to be held at 0.6 depth, or up to a velocity of about 3 ft. per sec., depending upon the depth.

For flood measurements, when the velocity is very great, the meter is usually held 1 ft. below the surface, and a coefficient of between 0.85 and 0.90 is used to reduce the velocity so determined to the mean velocity in that vertical.

In the top and bottom method velocities are taken at points 1 ft. below the surface and 1 ft. above the bed of the stream. The mean of these two velocities is taken as the mean velocity for the vertical. This method has especial advantages in low-water measurements of shallow streams.

In the integration method the mean velocity for the vertical is determined by lowering the meter at a slow uniform speed from the surface to the bed of the stream, and then raising it to the surface. The velocity as indicated by the mean number of revolutions per second during the run is taken as the mean velocity for the vertical. In this method special care has to be taken in lowering the meter in order to avoid increasing the number of revolutions by the vertical motion. This method is used to good advantage in high-water measurements where, owing to the high velocity, it is difficult to hold the meter at any one point. It is also used for measurements under ice or where the conditions are such that the point method is not reliable.

During the recent conference of Eastern Hydrographers (noted in Engineering News of Nov. 12, 1903) one day was spent at the U. S. G. S. Gaging Station on the Susquehanna River at Harrisburg, Pa., in making measurements to compare the relative merits of the above methods of determining

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velocity. At the Harrisburg gaging station the river is divided by a large island into two channels, each about 1,200 ft. in width. The bed of the river in these channels is made up of a gravelly material, over which is scattered a number of large boulders. The velocity measurements herein mentioned were made in the left channel at this station, and velocities varying from 1.52 ft. per sec. to 2.71 ft. per sec. were determined by each method at 20 different measuring points, having depths ranging from 3.2 ft. to 8.0 ft. The results of these determinations are shown by the accompanying table and curves. For comparing the various methods the results have been expressed in terms of percentage of the velocity found by the vertical velocity curve determinations.

Table Showing the Results of Velocity Determinations Made Nov. 2, 1903, for the Susquehanna River at Harrisburg, Pa.

Distance from initial point, ft.	Depth at measuring point ft.	Velocity in ft. per sec. by following methods: Vertical	Six-tenths	Top and bottom	Integration	P. ct. of vertical velocity: Top	Six-tenths	Top and bottom	Integration	Coefficient for reducing top to mean velocity	Depth of thread of mean velocity: In feet	In per cent. of depth
140	3.2	2.00	1.96	....	1.92	....	0.98	....	0.96	....	2.0	0.62
120	4.3	1.52	1.79	1.83	1.74	1.06	1.18	1.20	1.14	0.78	2.8	0.65
220	4.3	1.95	1.98	....	2.08	....	1.02	....	1.07	....	2.6	0.60
200	4.7	1.85	1.67	....	1.93	....	.90	....	1.04	....	2.6	0.55
160	4.8	1.82	1.87	....	1.74	....	1.03	....	.96	....	3.3	0.69
180	5.0	1.67	1.70	....	1.74	....	1.02	....	1.04	....	2.9	0 58
260	5.2	2.02	2.05	1.68	2.01	2.37	1.01	.83	1.00	.85	3.6	0.69
320	5.4	2.55	2.88	2.34	2.64	2.92	1.13	.92	1.04	.87	3.9	0.72
280	5.8	2.15	1.73	2.00	2.06	2.67	.80	.93	.96	.81	3.6	0 62
340	5.9	2.57	2.62	2.72	2.80	2.83	1.02	1.06	1.09	.91	3.5	0.59
380	6.0	2.63	2.35	2.81	2.62	3.02	.89	1.07	1.00	.87	3.9	0.65
300	6.0	2.44	2.48	2.57	2.37	2.79	1.02	1.05	.97	.87	3.7	0.62
360	6.1	2.71	2.85	2.75	2.72	2.99	1.05	1.01	1.00	.91	3.7	0.61
500	7.6	2.16	2.28	2.14	2.31	2.63	1.06	.99	1.07	.82	4.6	0.61
500	7.7	2.40	2.40	2.34	2.41	2.92	1.00	.98	1.00	.82	4.3	0 56
540	7.9	2.18	2.09	2.23	2.29	2.87	.96	1.02	1.05	.76	4.4	0.56
520	8.0	2.57	2.73	2.66	2.52	3.08	1.06	1.04	.98	.83	5.2	0.65
585	8.0	2.48	2.28	2.42	2.62	2.85	.92	.98	1.06	.87	4.6	0.58
580	8.0	2.48	2.33	2.32	2.46	2.80	.94	.94	.99	.89	4.1	0.51
580	8.0	2.49	2.49	....	2.48	....	1.00	....	1.00	....	5.5	0.60
Mean							1.00	1.001	1.021	0.847	....	0.613

An examination of the results in the table given by the various methods shows:

(1) That the mean of the 0.6 depth method practically gives the same velocity as the vertical velocity curves;

(2) That the integration method is liable to give velocities too large, owing to the fact that motion is imparted to the cups in moving the meter;

(3) That the velocity 1 ft. below the surface should be reduced about 15% to obtain the true mean velocity;

(4) That the thread of mean velocity as taken from the vertical velocity curves is practically 0.6 depth below the surface.

These conclusions are practically the same as have been reached in studying several series of similar measurements made under like conditions. The results, of course, vary slightly with different cross-sections, and in all stream measurements frequent vertical velocity curves should be made in order to test the other methods.

The accompanying diagram shows the vertical velocity curves with the points on which they are based, and also the relative location of the top and bottom and 0.6 depth measurements. The curves each end in a horizontal line, which represents the surface of the water. The dash under the lower end of each curve indicates the bed of the stream and the number over this dash refers to the measuring point at which the measurement was made. Each curve is plotted with reference to the heavy perpendicular line passing near its upper end. The numbers on these lines give the velocity in feet per second. These curves show:

(1) That in general as the depth increases the difference between the surface and bottom velocities decreases, and the curve becomes nearer vertical. This, of course, depends largely upon the conditions in the bed of the stream.

(2) That individual bottom velocity determinations are often quite variable, as shown in the determinations by the vertical velocity method and by the top and bottom method. On the other hand, individual top velocities agree quite closely.

In general, although the individual results show considerable range in the percentages, the mean of the percentages, however, is practically 100, which shows that the errors tend to balance each other. Inasmuch as an actual measurement consists in dividing the stream into 20 or more sections of about the same area and determining separately for each of these sections the velocity and discharge, the probable error in the total discharge will be comparatively small and far within the limits which should be expected in work where so many disturbing conditions exist.

FIVE DEATHS FROM CAISSON DISEASE have thus far occurred in the foundation work on the Manhattan Bridge, New York. Three of these men died on the Brooklyn pier foundation work, now finished, and two have died on the New York pier, now underway; of these two, one was an inspector who had gone down for the first time and collapsed in the air lock coming out. The Health Department has assigned a physician to examine all men who do caisson work, and to report on the best means of treating them when they come up. Each man works two shifts a day, of 1½ hours per shift, the interval between shifts being 4½ hours, and for his day's work receives $3.50. The depth at which they are now working is 92 ft., and it is not intended to sink deeper. It is reported that the Compressed Air Workers' Union has demanded $4 a day for 90 minutes' work, which the contractor has refused to grant, as he is securing a sufficient number of non-union men.

THE MILEAGE OF IMPROVED HIGHWAYS built in New York state under the State Engineer now numbers 299 miles, besides which 186 miles are in process of construction. Under the good roads law of 1898 the state bears half the cost of road improvement, and to that end the yearly state appropriations have been: 1898, $50,000; 1899, $50,000; 1900, $150,000; 1901, $420,000; 1902, $795,000; 1903, $600,000; making a total of $2,065,000. The counties have not only appropriated an equal amount, as required by the law, to make the state appropriations available, but they have in fact made appropriations far in advance. Up to Jan. 1, 1904, there have been 1,252 miles of road surveyed and planned, for which the counties have appropriated their half, or $5,540,587. Multiplying this sum by two and dividing by the total mileage, we see that the average cost is estimated at $8,860 per mile. As showing the remarkable popularity of the good roads law in New York state, attention may be called to the fact that up to date petitions for state aid have been received by the State Engineer for 4,143 miles of road improvement. In other words, for every mile of road already built under state aid, 14 miles of road have been petitioned for, which indicates the trend of opinion among farmers who, a few years ago, were supposed to be opponents of road improvement costing anything like $9,000 a mile. A bulletin issued by the State Engineer and Surveyor gives, in addition to the data above quoted, a list of the counties in the state and their respective appropriations. Monroe county, of which Rochester is the county seat, heads the list, with 52 miles of macadam roads already built, and 10 miles more under construction. Orange county will soon be first, as it has 40 miles already built and 45 miles more under construction. As was to be expected, the counties having the densest rural population have been the foremost in taking advantage of state aid, and these counties, of course, lie near the large cities.

The bulletin shows that the average length of each macadam road thus far built is 2 miles, while the average length of the 1,252 miles will be 3½ miles per road, there being 375 roads for which the counties have thus far made appropriations.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a butting collision on the Chicago, Rock Island & Pacific Ry. near Willard, a dozen miles west of Topeka, Kan., on Jan. 6. About twenty-five persons were killed in the wreck. The collision involved a westbound through passenger train, bound from Chicago to the Pacific Coast, and an eastbound stock train. The passenger train had orders to pass the stock train at Willard. Seeing a freight train in the siding at Willard, the engineer of the passenger train took this to be the stock train, and ran ahead. Nearly all the dead were passengers on the westbound train, the forward coach telescoped the one behind, and few in the latter car escaped.

A FATAL ELEVATED RAILWAY COLLISION occurred on the Kings County Elevated Ry., New York, N. Y., on Jan. 7. This line is operated mainly by electricity, but some trains drawn by steam locomotives are still run in the rush hours. One such steam train stopped at one point on the line to adjust a coupling. A following electric train ran into the rear of the steam train and caused the death of three trainmen who were working at the coupling. The motorman of the following train claims that steam and smoke obscured the train ahead, and that the line signal was set in his favor; the latter fact is corroborated by the towerman. The forward train had no back flag out.

THE PUGET SOUND STEAMER "CLALLAM" FOUNDERED just outside Victoria, B. C. (Canada), on Jan. 8 and about fifty persons were drowned, most of them passengers. The vessel made daily trips between Seattle, Wash., and Victoria, B. C., both of which cities lie on the Sound. During the trip of Jan. 8 from Seattle to Victoria, heavy weather was encountered at the head of the Strait of Juan de Fuca, between Port Townsend, Wash., and Victoria. The vessel sprung a leak which could not be handled, and began to sink. Several boats which set out loaded with passengers were capsized. Later a tug reached the "Clallam" and succeeded in taking off most of the persons on board before the steamer sank. The "Clallam" was built at Tacoma, Wash., less than a year ago.

RAILWAY SERVICE ACROSS THE NEW WILLIAMSburg bridge is still unprovided and no arrangements have been made with any of the street railway companies of Manhattan or Brooklyn to furnish such service. As shown in our issue of Dec. 17, the bridge has four lines of tracks for surface cars, and a recent proposition is that two of these shall be given up to cars of the Metropolitan Street Railway Co. operating in Manhattan and the other to cars of the Brooklyn Rapid Transit Co. Each company would run its cars across the bridge and turn them at the opposite end around a series of loop tracks similar to those now in use at the Manhattan end of the Brooklyn bridge.

ANOTHER BALLOT ON THE METRIC SYSTEM is being taken by the National Association of Manufacturers. A ballot taken two years ago resulted in a large majority against any legislation to make the use of the system compulsory in any of the Government departments. Since that date the membership of the association has increased about 200% and a new ballot is therefore being sent out.

Since the first ballot was taken the adverse vote then expressed has been concurred in by the following associations: The American Society of Mechanical Engineers, The Railway Master Mechanics' Association, The Master Car Builders' Association, The Furniture Association, The National Metal Trades Association. Similar action had already been taken by the Association of Machine Tool Builders, The Engine Builders' Association, The Society of Naval Architects and Marine Engineers, The Society of Heating and Ventilating Engineers and The Providence (R. I.) Society of Mechanical Engineers.

The metric bill is again to be pressed in the present Congress and hearings upon it are likely to be held some time this month.

ACCEPTANCE TESTS OF A 4,000-HP. STEAM TURbine built by Brown, Boveri & Co., of Baden, Switzerland, for the Frankfurt a. M. municipal electric plant gave the results summarized in the table below. The turbine is designed for 175-lb. steam pressure with a superheat of 300° C. At 1,360 r. p. m. its normal capacity is 2,600 KW. The direct-connected alternator produces current at 3,000 volts. The machine is without difficulty run in parallel with alternators driven by reciprocating engines. The mean steam consumption under different conditions was found to be as follows:

Steam pressure, lbs. per sq. in.	Superheat, Deg. F.	Load, KW.	Vacuum, % of Barom.	Steam consumption, lbs. KW.-hr.
171	193	1,945	93.2	15.8
174	186	2,518	91.8	14.7
141	240	2,995	90.0	14.7

A TRAVELING PLATFORM INCLINE of unusual dimensions has been constructed at the city of Biarritz, France, to convey pedestrians up the steep bluff separating the upper and lower levels of the city. The total height overcome by the incline is 17.67 m. (59 ft.), and this is done in two stages. The first incline ascends to the right to a short landing about midway up the cliff, and the second ascends to the left from this landing to the top of the cliff. Both inclines have a grade of 30° and are 37.5 m. (123 ft.) and 21.3 m. (69 ft. 10 ins.) long, respectively. Both inclines are 0.9 m. wide between railings and 0.48 m. wide in the tread. They are of the Reno type.